IDENTIFYING CHANGES IN PHYSICAL ACTIVITY BEHAVIOURS THAT LEAD TO WEIGHT GAIN IN FIRST YEAR UNIVERSITY STUDENTS

By

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ABSTRACT

The transition to university is a critical time period for weight gain, possibly explained by a decrease in physical activity. The aim of this study was to identify changes in physical activity as students' transition from high school to university and to assess if they relate to body weight and composition. Three hundred one (71 males, 230 females) first year Brock University students participated. Anthropometric and body composition data were collected in September and April. Students also filled out questionnaires assessing their physical activity behaviours. Significant increases in weight, BMI, and body composition were observed across the sample, accompanied by reductions in physical activity output and increases in factors preventing physical activity participation. However, the reductions in physical activity were not correlated with the changes in body composition. Therefore, in our sample, changes in physical activity behaviours are not the main cause of weight gain in first year university students.

Keywords: **weight gain, body composition, physical activity, first year university**

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ABBREVIATIONS

BIA	Bio-electrical Impedance Device
BMI	Body Mass Index (kg/m^2)
BMR	Basal Metabolic Rate
BMX	BodyMetrix
ECW	Extracellular Water
FFAQ	Food and Activity Questionnaire
FFM	Fat Free Mass
FIIT	Frequency, Intensity, Time, Type
FM	Fat Mass
lbs	Pounds
ICW	Intracellular Water
kg	Kilograms
MET	Metabolic Equivalent
MET-h	MET hour
NIH	National Institutes of Health
PA	Physical Activity
SAT	Subcutaneous Adipose Tissue
TBW	Total Body Water
VAT	Visceral Adipose Tissue
WHO	World Health Organization
WHR	Waist to Hip Ratio

CHAPTER 1: Introduction

1.1 Rationale

When looking at trends in weight gain, a critical time period for weight gain appears to be in young adulthood, especially during the transition from high school to university [1]. For most young adults, this transition and the adaptation to university life involves a dramatic change in environment which tends to result in weight gain [2]. In popular culture, this weight gain is commonly referred to as the 'Freshman Fifteen'. Past research on students in first year university has demonstrated that students do in fact show significant increases in body weight, although this weight gain has typically been less than 15 lbs (6.8 kg) [3]. The literature has proposed four main factors that may lead to this weight gain among first year students: a decrease in physical activity, a change in dietary behaviours, changes in psychosocial well-being, and baseline health status [4]. However, discrepancies exist in regards to the average amount of weight gained, the relationship amongst these four factors, and whether sex plays a role in this transition [3].

It has been well documented that engagement in physical activity can help maintain a healthy body weight [5]. Although most students are aware of the benefits of engaging in physical activity, previous research has uncovered a general trend of reduced physical activity levels in first year university students, which often leads to weight gain [3].

The Brock Transition Study used a multifactorial, three-fold approach to examine the transition from high school to University, focusing on changes in physical activity, nutrition, and psychosocial well-being. This thesis focuses on physical activity changes that occur during the first year of university and assesses how these changes impact body weight and body composition in male and female university students.

1.2 Objectives and Hypothesis

Overall Objective and Hypothesis

The overall objective of this thesis is to identify the changes in physical activity that occur as Ontario students' transition from high school to university and undergo their first year of university, and to assess how these changes impact body weight and body composition. It is hypothesized that first year students at Brock University will engage in less physical activity, thus developing routines favouring reductions in energy expenditure, which will result in weight gain throughout the academic year.

Specific Objectives and Hypotheses

1. To identify changes in body weight and body composition that occur among students during first year at Brock University. Significant changes in weight and body composition are expected across the sample, favouring increases in fat mass and decreases in lean mass.
2. To characterize the physical activity behaviours that students engage in, based on frequency, intensity, time and type. It is hypothesized that there will be a decrease in both the quantity (frequency and time) and the quality (intensity and type) of physical activity that the students engage in.
3. To examine how changes in physical activity are related to body weight and body composition. It is hypothesized that the decrease in physical activity will be associated with increases in both fat mass and body fat percentage.

CHAPTER 2: Review of the Literature

2.1 Health Risks Associated with Excess Body Weight

2.1.1 Overweight and Obesity on a Global Scale

Obesity has become a global epidemic and a serious public health issue [6]. Paradoxically co-existing with undernutrition, global overweight and obesity are increasing at alarming rates. Worldwide obesity has more than doubled since 1980 and is still on the rise [6]. In 2014, more than 1.9 billion adults (aged 18 years and older) worldwide were classified as overweight. Among these, 600 million adults were classified as obese.

Historically, self-reported data have been used to assess the health status of Canadians. However, this method of assessment is prone to underestimate the actual prevalence of overweight and obesity within the population. In 2007, the Canadian Health Measures Survey (CHMS) was launched. This survey obtained direct physical measurements from the population in order to achieve a more accurate determination of the health status of Canadians [7]. From January 2012 to December 2013, Cycle 3 of the CHMS was conducted. Based on the measured data, approximately one in five (5.3 million) Canadian adults aged 18-64 years were classified as obese. The prevalence of obesity was 21.8% among men, and 18.7% among women. When combining those who were classified as obese with those who were overweight, the prevalence increased to 61.8% of men and 46.2% of women [8]. Similar results were obtained from the Canadian Community Health Survey (CCHS) in 2014. Approximately 8.2 million men and 6.1 million women measured within high health-risk categories [9].

The same pattern is also apparent in the health status of Canadian children and adolescents. When comparing recent CHMS data to the results from the 1981 Canadian Fitness Survey, a significant increase in the incidence of overweight and obesity is apparent. Since 1981, the prevalence of overweight and obesity among children (aged 5-17 years) has doubled, and has tripled among adolescents aged 15-19 years [7]. CHMS data on the health status of Canadian youth (aged 12-17 years) indicated that nearly one in four (23.1%) Canadian youth were classified as having excess body fat, putting them at an increased health risk [10]. Of these, 16.9% were classified as overweight, and 6.2% were classified as obese.

2.1.2 Assessing the Health Risk Associated with Excess Body Weight

BMI is a commonly used screening tool and risk factor for numerous metabolic conditions and diseases that can occur as a result of excess body weight. While BMI has been shown to correlate with adiposity, general health status, and disease risk on an epidemiological/population level, it should be considered as a rough estimate of health as it does not assess the exact amount of fat in an individual, nor does it distinguish between fat mass and fat-free body mass (muscle, bones, organs) [11]. As a result, inaccuracies in BMI measurements might be seen in individuals who are extremely tall, extremely short, extremely lean or extremely muscular. In addition, research has demonstrated that different thresholds of BMI should be used to assess the health risks among certain ethnic groups. Individuals of African American, Asian, or Native American descent often require lower BMI thresholds to define obesity and certain health related disease risks [12].

Research has demonstrated that abdominal adiposity has a greater association with mortality and morbidity versus fat deposited in other areas of the body (such as around the hips or appendages) [13]. As such, waist circumference and waist to hip ratio (WHR) are often used as an alternative tool to measure general health and the risk of developing serious health conditions. Recent data has demonstrated that waist circumference and waist to hip ratio are strongly predictive of disease risk in young and middle aged adults, and are superior to BMI in assessing health status within this population [11].

Health and disease risk can also be assessed by examining body composition. A measure of body fat includes both essential body fat, and storage fat [14]. Essential body fat is necessary for maintaining life and reproductive function, and is typically around 10-13% of bodyweight in women and 2-5% of bodyweight in men. Storage fat, consisting of internal storage fat, subcutaneous adipose tissue (SAT), and visceral adipose tissue (VAT), is additional adipose tissue deposited under the skin that protects the body's internal organs, provides insulation, and is used as an energy source. While having a certain percentage of body fat is vital for life, too much body fat can pose serious health risks [14]. Ideal body fat percentages for an individual vary depending on age and gender, and are described in the table below (Table 1) [15].

Table 1. Percent Body Fat Norms For Men and Women

Description	Women	Men
Essential Fat	10-13%	2-5%
Athletes	14-20%	6-13%
Average	21-24%	14-17%
Above Average	25-31%	18-24%
At Risk	>32%	>25%

Reproduced from [16].

2.1.3 Health Concerns Related to Excess Adiposity

Accumulation of excess body fat is a major public health concern that leads to a plethora of health problems. Studies show that overweight and obesity are key risk factors for many non-communicable diseases, including cardiovascular disease, type 2 diabetes, insulin resistance, musculoskeletal disorders, and cancer [5]. These health related conditions caused by overweight and obesity result in an estimated 2.8 million deaths worldwide each year [26].

Overweight and obesity are also major health concerns for children and adolescents. In the past decade the rates of overweight and obesity in children and adolescents have more than doubled [17]. This poses a huge health risk to these individuals as it is well documented that once excess weight is gained, it is difficult to lose [18]. Additionally, numerous health conditions previously seen solely in adults are becoming more common in younger individuals. Conditions resulting from excess body weight, such as pre-diabetes, insulin resistance, sleep apnea, musculoskeletal disorders, and risk factors for cardiovascular disease, are becoming more and more common in

adolescents and young adults [19]. This is a serious issue as the younger an individual gains weight in the form of adipose tissue, the greater chances they have of developing even more serious health complications as they get older and/or suffering from premature death [19].

2.1.4 Young Adulthood as a Critical Period for Weight Gain

The first step in developing strategies for obesity prevention is by identifying critical periods of weight gain. This will allow for a better understanding of the factors that contribute to the weight gain and will aid with the development of effective interventions that can then be targeted directly to the individuals within these critical periods. A study conducted by Mokdad et al. (1999) demonstrated that young adulthood was one such critical time period for weight gain, and that young adults (including college/university aged individuals) experience some of the greatest increases in the prevalence of overweight and obesity [20]. When examining the timing of this weight change, Anderson et al. (2003) identified that the first year of university was when the majority of this weight gain occurred [1]. In addition, studies show that young adults attending their first year of university or college exhibit greater changes in weight than their age-matched counterparts not attending school [21]. For example, women enrolled in their first year of university were 3.8 times more likely to gain weight than women of the same age not attending university [21]. Similar results were found by Mihalopoulous et al. (2008), where first year students were 6 times more likely to gain weight than age-matched community controls [22].

For most young adults, the transition from high school to university involves a dramatic change in environment [3]. Students often start living away from home and get more freedom and responsibilities than previously accustomed to. This transition may bring with it the change or abandonment of previously established routines and behaviours from high school, and the adoption of new lifestyle habits [23]. Unfortunately, many students adopt new risky health behaviours, such as smoking tobacco, consuming alcohol, engaging in less physical activity, perceiving and incurring higher levels of stress, reducing hours of nightly sleep, and adopting unhealthy dietary habits. This is of concern as the lifestyle habits that are adopted in university, are often carried into adulthood [24].

2.2 Weight Gain in First Year University Students

2.2.1 Defining the 'Freshman Fifteen'

The 'Freshman Fifteen' is a popular expression used among Canadians and Americans, referring to the 15 pounds of unwanted weight that students are believed to gain in first year university. The first academic reference to first year weight gain appeared in the journal *Addictive Behaviours* in 1985 where a weight increase of 8.8kg was reported among first year students [21]. In 1989, *Seventeen Magazine* published an article about this weight gain and coined it the 'Freshman Fifteen' [25]. Since then, the amount of material on the 'Freshman Fifteen' in newspapers, magazines, web-sites and academic journals has increased exponentially [26].

2.2.2 Overview of Weight Change in First Year University Students

Due to the 'Freshman Fifteen's' pervasiveness in popular culture, researchers have begun to investigate whether first year students do in fact gain 15 pounds (6.8kg) over their first university year (Table 2). Recent articles investigating this phenomenon have indicated that first year students do in fact gain weight in first year, however on average it is much less than fifteen pounds [3]. These reports have examined changes in the weight of first year students, over their first or first few semesters of university. A recent study by Zagorsky (2011) assessed data from the National Longitudinal Survey of Youth 1997 cohort (NLSY97) and found that the change in weight among first year university students averaged 1.3 kg (2.9 lbs) [2]. When examining only the individuals who gained weight, women gained an average of 4.0 kg (8.9lbs) and males gained an average of 6.1 kg (13.4lbs). In addition, only 10 percent of first year students gained fifteen pounds or more, and 25 percent of students lost weight in their first year. An analysis conducted by Crombie et al. (2009) examined 17 longitudinal studies that followed students over either their first semester or both semesters of first year university [3]. The average weight gain among students over both semesters averaged 2.0 kg (4.4lbs). When examining only the individuals who gained weight, the average weight gain was approximately 3.0 kg (6.6lbs) over the year. A meta-analysis examining first year weight gain in 24 studies found similar results [4]. The mean change in weight among university students over the course of their first year of studies was 1.7 kg (3.8lbs).

These studies have demonstrated that while a significant amount of weight is gained during first year, cases where students gain fifteen pounds are rare. Indeed, these

papers report average weight gain so it is possible that individual students may gain upwards of 6.8 kg (15 lbs) or more. However, from the reported literature, it seems that students are more likely to gain closer to 2.3kg (5.0 lbs) than 6.8kg (15 lbs). As Holm-Denoma (2008) suggests, the term "Freshman Five' might be more accurate than 'Freshman Fifteen' in describing the amount of weight first year university students should anticipate gaining [27].

2.3 Factors Leading to First Year Weight Change

Upon reviewing the literature it is evident that more often than not weight is gained by students in first year university [3]. Nonetheless, researchers have not yet been able to come to a clear consensus on how the numerous lifestyle changes and weight promoting factors interact and lead to this weight gain. While increases in body weight are often a result of decreased physical activity levels and poorer quality/increased quantity of dietary intake, several other predictors for weight gain have been identified. Four main theories for predicting weight gain in first year university students include: changes in physical activity, poor dietary habits, baseline health status, and poor psychological health [3].

2.4 Physical Activity

2.4.1 Physical Activity and Health

There is a large body of evidence supporting the essential role of regular physical activity and exercise for the maintenance of good health and well-being [28]. Regular physical activity has been shown to aid in maintaining a healthy body weight,

maintaining bone health and muscular strength, improving mental health and mood, and making activities of daily living easier [29]. In addition, regular physical activity reduces the risk factors (including high blood pressure, high blood cholesterol, and high BMI) for many non-communicable diseases (NCDs) and chronic health conditions such as cardiovascular disease (CVD), type 2 diabetes and metabolic syndrome.

While the exact type, frequency and intensity of physical activity required to improve and maintain health remains unclear, the inverse association between physical activity and premature all-cause mortality is evident [30]. In fact, studies have shown that individuals who achieve the minimum 150 minutes (2.5 hours) per week of physical activity, as recommended by the Canadian Society for Exercise Physiology (CSEP), have a 19% reduction in the risk of all-cause mortality compared with inactive individuals (0 hours/week) [7]. As well, compared with inactive individuals, engaging in 1 hour of physical activity, 7 days per week reduces all-cause mortality by 24% [30].

2.4.2 Physical Activity Recommendations

Canada's Physical Activity Guidelines, created by CSEP, state that adults aged 18-64 years should engage in 150 minutes of moderate to vigorous intensity aerobic physical activity per week, in bouts of 10 minutes of more [31]. Similarly, the American College of Sports Medicine (ACSM) also states that adults should achieve a minimum of 150 minutes of physical activity per week, achieved through 30-60 minute bouts of moderate-intensity exercise five days per week, or 20-60 minutes of vigorous-intensity exercise three days per week [32]. These guidelines have been created to ensure that adults are engaging in levels of activity sufficient to maintain a healthy body weight and

achieve the health related benefits from physical activity, such as chronic disease prevention and improved mental health.

2.4.3 Classifying and Measuring Physical Activity

The FITT principle is an effective method of monitoring an individual's physical activity program. The acronym FITT outlines the key components of an effective exercise program: frequency, intensity, time and type. These four principles can be applied to low, moderate, and high intensity training as well as both cardiorespiratory and resistance training workouts [33].

Another commonly used method of assessing physical activities with different intensities is by using metabolic equivalents (METs) [34]. METS are physiological measurements that express the energy cost (or caloric expenditure) of an activity. One MET is the equivalent of the energy expended at rest (1 MET = 3.5 ml O_2/kg/min for a 70kg person). Physical activities and exercises can be performed over a number of intensities (or METs), ranging from light to vigorous. According to Godin and Shephard, a low intensity activity (ex: walking) ranges from 2-4 METs, a moderate intensity activity (ex: leisure biking) ranges from 5-8 METs, and a vigorous intensity activity (ex: running) ranges from 9 METs or higher [35].

2.4.4 Physical Activity Levels in First Year University Students

Although most university students are aware of the benefits of physical activity and exercise, previous literature demonstrates that the majority of students entering into their first year of university do not meet these physical activity recommendations [36].

The National College Health Risk Behaviour Survey (NCHRBS, 1995) indicated that while 38% of students engaged in regular vigorous activity and 19% of students engaged in regular moderate physical activity, an astounding 43% of university students did not engage in physical activity on a regular basis [37]. A more recent investigation by the Canadian Association of College and University Student Services (CACUSS) in 2013, found that 42% of university students in Ontario reached the minimum physical activity recommendations, while 58% of students did not participate in adequate amounts of physical activity. Pinto and Marcus (1995) had similar findings; their data indicated that in a sample of 217 freshman, 42% of women and 50% of men engaged in regular physical activity, although less than the recommended 3 days per week [38]. Only 28% of their sample population achieved the recommended amount of physical activity.

These observations have led many researchers to the conclusion that the one of primary causes of weight gain in first year students is a reduction in the quality and quantity of physical activity and regular exercise [36] (Table 2). In 2004, Butler et al. examined how changes in physical activity levels lead to changes in weight in female first year university students. The Baccke Physical Activity Questionnaire was used to assess work, sport, leisure time and total physical activities. Despite decreases in energy intake, weight gain occurred across the study sample, and was associated with decreases in work, social and total physical activity time, and increases in sedentary activities [36].

Similar results were found by Jung et al. (2008). In this study, the physical activity levels of first year university women were measured by MET h/week using an adapted version of the Godin-Shephard Leisure Time Questionnaire (GLTQ). While no change was seen in MET h/week among individuals who maintained their weight, a

significant decline in MET h/week occurred amongst the individuals who gained weight. Further analysis of MET h/week values throughout the academic year revealed that for both the weight maintainers (34%) and weight gainers (66%), the greatest decline in MET h/week occurred during the first 8 weeks of university. After this point, the individuals who were able to return to their baseline physical activity patterns also returned to their baseline weight. As caloric intake remained equal across the sample, the researchers were able to identify the reduction in physical activity among first year students, especially during the first 8 weeks of school, as the main predictor for weight gain [39]. To determine whether these changes occurred due to fat loss/gain or muscle loss/gain, body composition was measured by bio-electrical impedance analysis (BIA). When examining the students that gained weight, a significant increase in percent body fat was seen. However, the results are limited due to the fact that male students, as well as any students living off campus, were excluded from participating in this study.

An investigation by Kasparek et al. (2008) revealed that the frequency in which first year students engage in physical activity was more important than the intensity of the activity. Students who participated in low intensity activities (such as walking or yoga) at a high frequency ($\geq$ 4 sessions per week) had a lower follow-up BMI than individuals who participated in moderate or vigorous activities (such as running or resistance training) at low frequencies (0-3 sessions per week) [40].

This pattern of inactivity in university students is of great concern, as the physical activity habits that students develop in university have a long-term impact on physical activity habits during adulthood [24]. Physical activity patterns established during university are generally maintained throughout adulthood, and can predict long-term

health outcomes. A longitudinal study conducted by Sparling and Snow (2002) on university alumni 5-15 years after graduation, revealed that 84.7% of university alumni who were regular exercisers in university were just as active or more active at the time of the survey. Additionally, 81.3% of the alumni who were inactive as a university student reported being just as inactive or even less active at the time of the survey [24].

2.5 Determinants of Physical Activity

Physical activity participation is a highly variable behaviour, and is determined by a number of different factors [18]. Past studies examining physical activity engagement have uncovered three main factors that influence physical activity participation among first year university students, which include intrapersonal factors, interpersonal factors, and structural factors [18, 41]. Intrapersonal factors are factors that exclusively affect the individual and include such things as self-confidence and motivation. Interpersonal factors are related to the social relationships of an individual. Arzu et al. (2006) observed that interpersonal barriers, including peer influences, were the greatest barriers to physical activity participation in university students [42]. These results are consistent with the findings of Keating et. al (2005), Resnick et. al (2006), and Deliens et. al (2015) [18, 41, 43]. Structural factors are personal, policy and environmental barriers that include such things as class schedules, fees, and available facilities.

Understanding why students engage, or do not engage, in physical activity is important for the development of interventions to encourage healthier lifestyles. According to Lovell, the perceived barriers to physical activity participation are the main predictors of health behaviour changes, therefore identifying the barriers to students'

physical activity participation is essential to create effective intervention programs [18, 44].

2.6 Assessing Changes in Body Composition

Percent body fat can be measured by a variety of techniques, some being more accurate and reliable than others. Within this thesis, body composition was measured using ultrasound with the BodyMetrix (BMX) device (BodyMetrix^{TM} System, BX-2000, IntelaMetrix, Inc., Livermore, CA) and using Bioelectric Impedance Analysis (BIA) (Lunar In-Body 520, Biospace, GE Healthcare, Madison, WI).

The BodyMetrix system, which is a relatively new device for assessing body composition, uses A-mode (amplitude mode; in which amplitude is displayed along the vertical axis and depth is displayed along the horizontal axis) ultrasound technology to measure body composition (Figure 1). The ultrasound waves travel through the body and measure the fat and muscle thickness at each measurement site. Strong reflections occur at the fat-muscle and muscle-bone boundaries (Figure 2). The reflected signals are recorded and used to provide measures of fat thickness and percent body fat [45].

The measurements provided by this device are not affected by exercise levels, hydration, or caffeine levels, allowing for greater accuracy in its results [45]. To date, the sole limitation of this device is the variation between researchers taking the measurements. The BMX system has been reported to produce accurate and reliable measurements of percent body fat in both healthy [46] and overweight subjects [47].

Figure 1. Image of a typical measurement using the BMX software. The vertical axis in 'Measurement Data' demonstrates the tissue thickness and the vertical axis demonstrates the corresponding amplitudes.

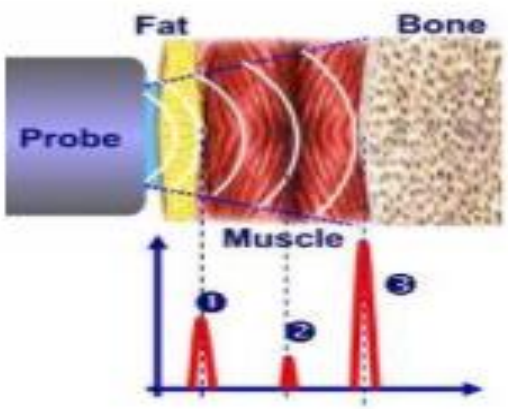


Figure 2. The first peak is the fat-muscle boundary. The smaller peaks are different interfaces which can include connective tissue, or fat in the muscle layer. The last peak is the muscle-bone interface which ultrasound does not penetrate [45].

The 8-point Lunar In-Body 520 BIA system is a commonly used method for assessing body composition [48]. The BIA device measures electrical impedance in the body, that is, the flow of an electrical signal through fluids in the body. Electrical signals pass quicker through fluids than through non-fluids. Therefore, impedance is low in fat-free mass (FFM) which is comprised of 70-75% water, allowing the signal to pass through much faster than in fat mass (FM), which contains much less water (10-20% water). The BIA also provides a measure of total body water (TBW) from which values for FFM and FM can be determined. BIA has also been deemed as a valid tool for tracking changes in body composition and for performing group comparisons in nutritional and sport medical research [49]. Percent body fat measurements comparing the BMX system with the BIA device have demonstrated consistent correlations (r=0.91, p=0.01) [46], and (r=0.86, p=0.01) [50] in healthy adults. However, as the BIA device is highly sensitive to the hydration level of the body tissues, the hydration status of the subjects is the main limitation of this device [51]. Eating, fluid intake, alcohol intake, and physical activity can alter hydration status within individuals. Therefore, care should be taken to instruct subjects to avoid eating, drinking, and being physically active before testing [48].

2.7 Current Limitations in the Literature

Knowledge about how the physical activity habits of students change during the transition into university will allow researchers to develop effective interventions to combat this issue [18]. While numerous studies have been conducted to investigate the effects of this transition, few studies have assessed the relationship between physical

activity and body composition. In general, most research on physical activity has focused on the proportion of physically active to inactive students, and on exercise and physical activity preferences [36]. In addition, most researchers have used the concepts of physical activity and exercise interchangeably in their research, even though exercise is only one aspect of physical activity. Furthermore, the body of research on this topic is limited due to the inconsistencies in the measurements of physical activity [18]. To measure physical activity, one should consider the frequency, intensity, time, and type of the activity [33].

The Brock Transition Study has adopted a novel approach to assessing this transition by measuring the physical, physiological and psychological changes that occur within this transition. Although several studies have assessed changes in physical activity and diet, few studies have looked at the effect of these factors together on weight gain. In addition, although the link between mental well-being and weight gain has been proven, there is a lack of literature examining this relationship in first year university students. Therefore, in order to determine the factors that are associated to weight gain in first year, physical activity, diet, and psychosocial well-being must all be examined together. This research will help clarify the existing discrepancies and limitations in the literature and will help to lay a foundation for future projects.

2.8 Summary

Despite past research conducted on first year student, or ‘freshman’ weight gain, there is a lack of consistency regarding the amount of weight typically gained in first year university and the factors that lead to this weight gain. However, in order to determine the factors that lead to weight gain during the first year of university, physical activity, diet,

and psychosocial health must all be examined together. Therefore, **this thesis aims to identify/characterize the changes in physical activity behaviours among first year students as they transition from high school into university and undergo their first year in university, and to assess how these changes are associated with body weight and body composition.** This thesis was part of a larger study (The Brock Transition Study) and only select data pertaining to physical activity, exercise and body composition will be discussed within this document.

Table 2. Studies assessing Weight Gain Among First Year University Students. Each of these studies measured Physical Activity in some form.

Reference	Sample Size (n) Men/Women		Study Duration	Avg. Weight Change	Predictors of Weight Gain Examined	Predictors of weight gain found / NOTES
Deforche et al., 2015 [34]	n = 291	NR	30 months	6.0lbs (2.7kg) m= 9.3lbs f= 4.2lbs	- Physical activity - Sedentary behaviours - Nutrition	- Active transportation and sport participation decreased - Sedentary studying behaviours increased - Alcohol consumption increased and fruit/veg intake decreased
Nicoteri et al., 2014 [67]	n = 125	19 / 106	48 months	n/a	- Initial BMI	- Individuals who enter university with a high BMI will maintain that high BMI
Takomana et al., 2012 [36]	n = 47	26 / 21	7 months	18.7lbs (8.5 kg)	- Anthropometrics - Physical activity - Nutrition	- Increase in light and sedentary activities - Reduction in fruit and veg intake / increase in meat and wheat intake
Finlayson et al., 2011 [67]	n = 120	22 / 98	12 months	4.6lbs (2.1kg)	- Eating behaviour traits - Physical activity - Baseline weight	- FM increased due to increase in food consumption - Increased FFM related to increased PA in conjunction with the drive to experience palatable food/rewards
Economos et al., 2008 [67]	n = 396	140 / 256	8 months	5.3 lbs (2..4kg) m= 5.0lbs f= 5.5lbs	- Stress (perceptions & responses) - Physical activity - Nutrition - Alcohol consumption	- High stress related to weight gain in both M and F - M: lack of academic confidence + peer pressure + greater alcohol consumption = weight gain - F: stress + increased workload = weight gain
Holm-Denoma et al., 2008 [39]	n = 607	266 / 341	9 months	3.75 lbs (1.7kg)	- Diet - Dietary behaviours - Self-esteem	- Most weight gain occurred in first 12 months - PA frequency and relationship with parents predicted weight change
Jung et al., 2008 [49]	n = 101	0 / 101	12 months	3.1 lbs (1.4kg)	- Physical activity - Diet	- Decline in PA (especially within the first 8 weeks) is the main contributor to weight gain
Kasparek et al., 2008 [50]	n = 193	24 / 169	6 month	2.5 lbs (1.1kg)	- Physical activity - Diet - Alcohol consumption	- Weight gain was associated with initial BMI (≥ 25), low frequency PA, increased alcohol consumption, and poor diet (less fruit/veg)

Milalopoulos et al., 2008 [33]	n = 126	64 / 62	4 months	2.7 lbs (1.2kg)	- NR	- NR
Pullman et al., 2008 [51]	*n* = 108	108 / 0	8 months	6.6lbs (3.0 kg)	- Physical activity - Sleep	- Vigorous PA decreased - Light activity, strength training, & flexibility training did not change - Sedentary activities increased - Hours of sleep decreased
Racette et al., 2008 **[63]**	n = 204	66 / 138	482 months	5.5lbs (2.5kg)	- Exercise habits - Nutrition	- Increased stretching and decreased aerobic activities - 50% engaged in regular PA, 30% did not engage in regular PA - Less fruit and vegetable intake and higher consumption of high fat foods
Hoffman et al. 2006 **[67]**	*n* = 67	32 / 35	7 months	2.8 lbs (3.1kg)	- NR	- NR
Morrow et al., 2006 **[67]**	n = 137	0 / 137	8 months	2.2lbs (1.0kg)	- Physical activity	- High baseline weight and fat mass - Decreased moderate and vigorous PA
Racette at al., 2005 **[62]**	n= 746	359 / 405	24 months	9.0lbs (4.1 kg)	- Physical activity - Diet	- NR
Butler et al, 2004 **[48]**	n = 54	0 / 54	4 months	1.6 lbs (0.7 kg)	- Physical activity - Diet - PA and dietary self-efficacy	- Reduction in PA responsible for weight changes - Increase in leisure / sedentary activities
Levitsky et al., 2004 **[32]**	n = 60	9 / 51	12 weeks	4.2lbs (1.9 kg)	- Physical activity - Diet - Sleep habits	- Increased consumption of evening snacks and high fat foods
Anderson et al, 2003 **[1]**	n = 135	58 / 77	8 months	3.7lbs (1.7kg)	- NR	- Weight gain occurred in the beginning of the academic year (Sept-Dec) and plateaued towards the end of the academic year.
Hovell et al., 1985 **[31]**	n = 158	00 /158	12 months	n/a	- NR	- NR

Abbreviations: F, female; M, male. NR, no data reported.

CHAPTER 3: Methods

3.1 Participants

This study and all related procedures received ethical clearance from the Brock University Research Ethics Board (REB # 13-297). Subject recruitment went on for 2 years. It began in the summer of 2014 during Brock University's SmartStart program (June-August 2014) and continued through the month of September 2014, and again during the summer of 2015, ending at the end of September 2015. Flyers were posted throughout campus and an information booth with researchers present was set up in the main dining hall during SmartStart lunch hours. In September, during the first two weeks of class, the researchers visited numerous first year classes and delivered a short presentation to inform the first year students about the study.

All participants were incoming first year students recruited from Brock University. Subject eligibility included both male and female students entering their first year of studies at Brock University between the ages of 17-20, with no previous university or college experience. After students expressed interest in the study, they were sent an individualized email containing further information about the study (invitation letter), and were provided with the consent form. Informed consent was to be obtained before commencing data collection. All subjects were given a code name to ensure anonymity.

3.2 Procedures

Participants were followed longitudinally for one academic year (8 months). Data collection occurred at two time points; first at the beginning of the fall semester (August -

September), and second at the end of the winter semester (March) (Figure 1). Upon receiving consent to participate, participants received a confidential link to a set of online surveys through the *Fluid Surveys* online survey program. The surveys included the Physical Activity Questionnaire for Adolescents, the Determinants of Physical Activity Behaviours Questionnaire, as well as several other questionnaires that do not pertain to this thesis. After completing the surveys, the participants were booked for a 30-minute lab visit in the Nutrition, Exercise, and Lifestyle Improvement Laboratory. All visits were booked during the hours of 8:00am - 11:30am. Participants were instructed to arrive at the laboratory in a fasted state (no food or drink for 8 hours prior). They were also asked to refrain from alcohol consumption for a minimum of 24 hours prior, and to refrain from exercise for a minimum of 12 hours prior to their lab visit. These guidelines were set in order to ensure that the participants' saliva was not diluted or contaminated with substances that might affect the immunoassay, and to ensure that the participants' body fluid levels were stable before being assessed with the bio-electrical impedance (BIA) analysis device. Saliva samples were not analyzed and BIA measures were not used for this thesis. Upon arrival to the laboratory, all participants verbally confirmed that all pre-testing parameters (listed above) were followed. In the lab, they completed a Food Frequency and Activity Questionnaire (FFAQ) [52], had anthropometric measurements taken including height, weight, waist and hip circumference, and had their body composition measured.

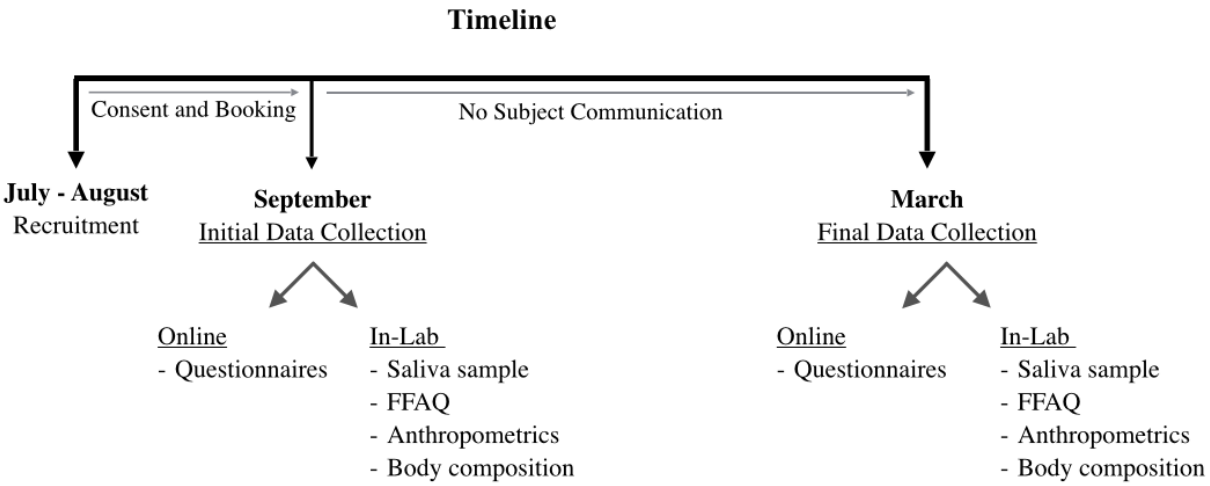


Figure 3. Brock Transition Study Timeline

3.3 Measurements

3.3.1 Anthropometric Measurements and Body Composition

Height and weight were measured without shoes and in light clothing using a stadiometer (Portable Fitness Scale 140-10-7N, Rice Lake Weighing Systems, Rice Lake, WI). Height was recorded to the nearest 0.1 centimetre (cm) and nearest 0.1 inch (in). Weight was recorded to both the nearest 0.1 pound (lbs) and 0.1 kilogram (kgs). Measurements of waist and hip circumference were performed using a retractable, inelastic measuring tape, and were recorded to the nearest 0.1 centimetre and nearest 0.1 inch. Measurements at the waist were taken at the level of the umbilicus, with the abdomen relaxed. Measurements of hip circumference were taken at the widest area of the hips/buttocks region, with the feet together.

Body composition was measured using both the BodyMetrix (BMX) device and the BIA device for comparison. For the BMX, we used the Jackson-Pollock setting [53]

to provide a three-site measure of percent body fat. The measurement sites for females included the thigh, triceps, and hip, and the measurement sites for males include the thigh, chest, and waist. All measures were taken on the left side of the body. If a participant was uncomfortable with having the ultrasound performed on one of the three areas or was wearing restrictive clothing the Pollock setting [53] was used to measure fat thickness in the waist, triceps, and hip in females or the chest, scapula, and triceps in males. Gel was applied to the ultrasound wand, which was then placed perpendicular to the measurement site and moved in a small line (1-2 inches) over the skin [50] for 3-5 seconds. Additional values of total fat mass, fat free mass, body mass index (BMI), and basal metabolic rate (BMR) were also recorded.

The Lunar In-Body 520 BIA device was used to provide an additional measure of body composition. The participants were asked to stand on the metal footplate and age, height, and gender were manually entered into the device. The participants were then asked to gently hold on to the handles with their arms relaxed by their side. A weak electrical current was generated at 3 frequencies (5, 50, 500kHz), and 15 impedance measurements at 5 segments (right arm, left arm, right leg, left leg, and truck) were calculated using a tetrapolar 8-point tactile electrode system. The procedure takes approximately 50 seconds to complete, and provided additional measures of intracellular water (ICW), extracellular water (ECW), total body water (TBW), ECW/TBW, BMI, and BMR. During the assessment, the BIA device assumes that the body is at its normal level of hydration. If an individual is hyperhydrated (from consuming fluids or alcohol, from engaging in exercise prior to the measurement, or from a menstrual cycle), or hypoydrated (from not consuming a sufficient amount of water) the percentage of FM is

overestimated [48]. Therefore, in order to ensure that all participants were well hydrated, they were all given 500mL of water to consume while completing FFAQ, and were then asked to void their bladder immediately before stepping on the device.

All measurements were performed by the same investigator at each time point. All data was recorded on an individualized data collection sheet (Appendix D).

3.3.2 Assessment of Habitual Physical Activity

Three questionnaires were used to assess the habitual physical activity levels of the participants: (1) The Physical Activity Questionnaire for Adolescents (PAQ-A), (2) The Determinants of Physical Activity Behaviours Questionnaire, and (3) The 2014 Block Food Frequency and Activity Questionnaire (FFAQ).

The Physical Activity Questionnaire for Adolescents (PAQ-A) (Appendix 2.2) was used to measure the general physical activity behaviours of the participants [54]. This 7-day recall questionnaire was designed to measure the general levels of physical activity of high school students (aged 14-17 years) and to provide a summary of activity over one week. For the purposes of this thesis, the PAQ-A was modified to measure general levels of physical activity of high school students over several months for the first time point (September). It was similarly modified to measure general levels of physical activity of university students over several months for the second time point (March).

The modified questionnaire consisted of two items. The first item of the questionnaire examined the changes in the frequency of engagement in different types of physical activities that students engage in, in high school compared to university. The physical activities were organized into three categories (1) endurance sports (including:

biking, cross-country skiing, floor hockey, jog/running, ice skating, in-line skating, skipping, street hockey, skateboarding, tag, and walking for exercise), (2) team sports (including: badminton, baseball, basketball, football, ice hockey, rowing, swimming, soccer and volleyball), and (3) fitness activities (including: aerobics, dance, martial arts, and yoga). The frequency of each activity was assessed using a 6-point scale; 1 being no participation and 6 being participated 10+ times. Once a value for each activity was assigned, the mean values for each category of activity were compared pre and post to determine if there was a change.

The second item examined students' free time physical activity habits. The participants were provided with a scale ranging from 1-4, 1 being no physical activity in their free time and 5 being physically active 7+ times per week in their free time, and selected the response that best described their usual habits. The values for each level were compared pre and post to determine if there was a change.

The Determinants of Physical Activity Behaviours Questionnaire (Appendix 2.1) was used to examine the barriers to students' physical activity participation as well as overall physical activity behaviours of the participants, and consisted of three items.

The first item of the questionnaire examined the barriers to students' participation in physical activity in high school compared to university. The barriers were divided into three categories (1) intrapersonal factors (including: shyness, stress, perceived self-skill, past bad experiences, lack of interest and fear of failure), (2) interpersonal factors (including: lack of friends, peer influence, gender, ethnic background, perceived body image, and age) and (3) structural factors (including: employment, homework, class schedule, income, distance of residence, lack of advertising, available free time,

transportation, participation fees, sports offered, and overcrowded facilities). Each factor was measured on a scale ranging from 1-5; 1 being strongly disagree and 5 being strongly agree. Once a value for each factor was assigned, the mean values for each category were compared pre and post to determine if there was a change.

The second item examined the participants' frequency of engagement in organized sports in high school compared to university. The participants were provided with a scale ranging from 1-5; 1 being 0-2 organized sports and 5 being 12+ organized sports. The values for each category were compared pre and post to determine if there was a change.

The third item examined the amount of participation in different levels of physical activity, including physical education classes, intramurals, competitive sports, recreational sports, and other activities. The values for each level were compared pre and post to determine if there was a change.

The 2014 Block FFAQ [52] (Appendix 2.3) was used to collect information on the frequency and duration of light, moderate and vigorous physical activities the participants engaged in on a weekly basis, and to measure total energy intake (kcal/day) as well as energy expenditure (kcal/day). The activity screener calculated the average number of MET minutes, light, moderate, and vigorous physical activity minutes that the students engaged in per week, and the average weekly energy expenditure for the six months preceding the survey [75]. From the answers provided, estimates of intensity of effort and total energy expenditure in kilocalorie and kilojoule units, were obtained [55]. All responses from this questionnaire were analyzed by NutritionQuest (Berkley, CA).

3.4 Statistical Analysis

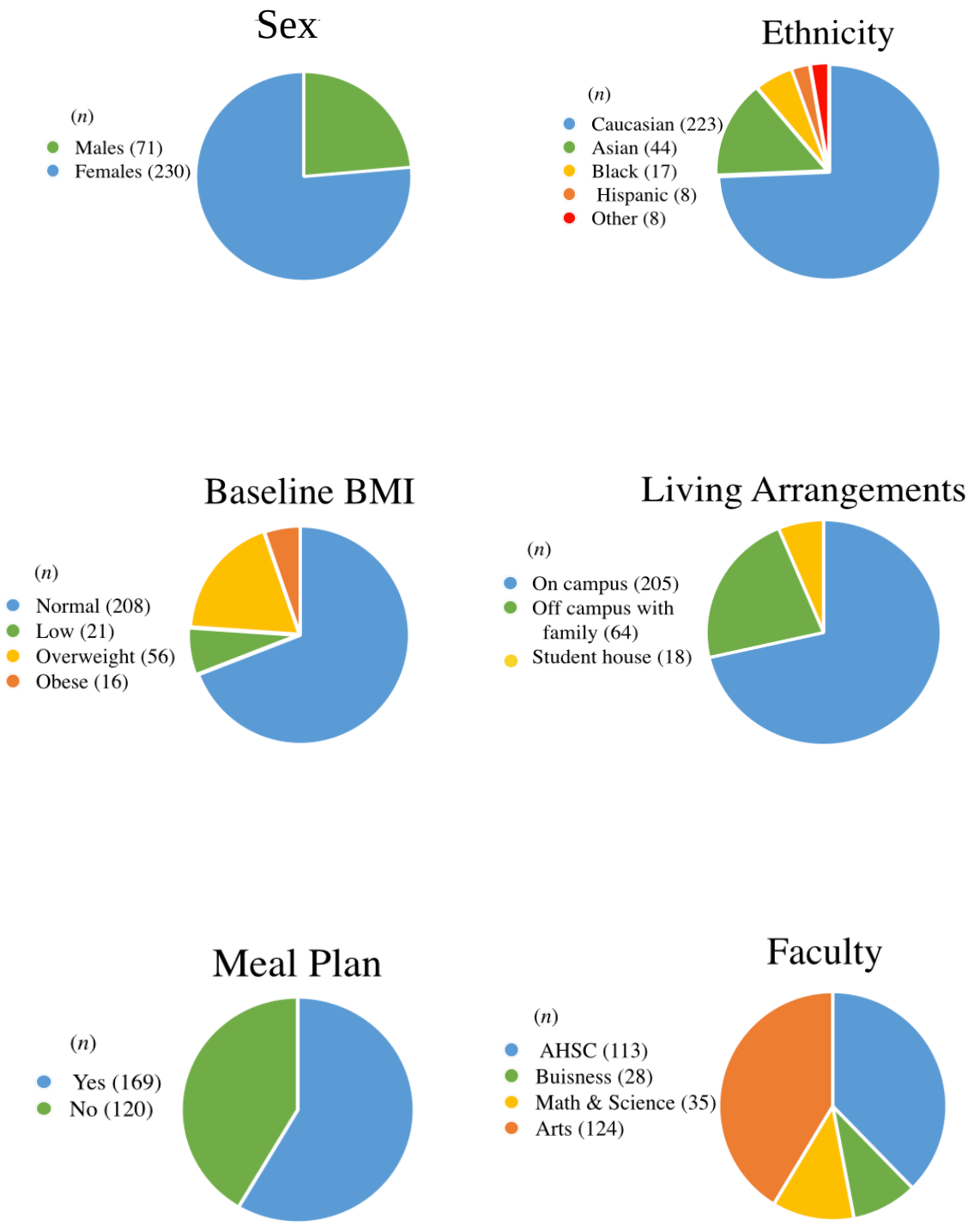
Statistical analyses were performed using SPSS version 20.0 for Windows. Descriptive statistics were used to provide information about the overall characteristics of the sample. Paired t-tests were used to compare all anthropometric measurements, body composition measurements, physical activity output values, and questionnaire output values, over the two time points (September and March) after stratifying by sex. Independent/unpaired *t*-tests were used to compare the changes in anthropometrics and body composition after stratifying by sex, among students that gained weight, baseline BMI status, meal plan type, and by weekly minutes of physical activity (<150 minutes or ≥150 minutes). One-way ANOVAs were used to compare the changes in anthropometrics and body composition based on living arrangements and faculty. All assumptions for t-tests and ANOVAs were assessed and met before data analysis occurred. Missing variables and outliers were replaced with series means. Data are reported in Tables as means and standard deviations and in Figures as means and standard errors. Significance was assumed at an alpha level of 0.05.

CHAPTER 4: Results

4.1 Demographic Data

A cumulative total of 1034 first year Brock University students expressed interest in the Brock Transition study. Of that, 365 students signed the consent form and completed the first lab visit and first set of online questionnaires. 301 students completed the second lab visit. Of the 301, 273 students completed both lab visits and both sets of online questionnaires (all data were collected). Therefore, the attrition rate of the study was 75%. The ratio of men (n=71, 23.6%) to women (n=230, 76.4%) who completed the study was slightly lower than the population of first year students at Brock University, which is approximately 57% female [56]. Of the 301 participants, 74.3% were Caucasian, 71% lived on campus, and 58% had a meal-plan. The demographic characteristics of the sample are presented in Figure 4.

Figure 4. Subject characteristics and demographic information.



4.2 Physical Characteristics and Body Composition

Table 3 depicts the change in anthropometric and body composition data of the participants at the beginning of their first year at Brock University and 8 months later at the end of the second term. Over 8 months the average weight change of the sample was a gain of 2.0 kg (4.4 lbs). Males gained an average of 3.6 kg (7.9 lbs) over the year and experienced a significant gain in lean body mass ($p<0.001$). Females gained an average of 1.7 kg (3.7 lbs) and experienced a significant gain in fat mass ($p= 0.001$). While the majority of the sample (79%) gained weight, large variations in weight change were observed, ranging from -9.4 kg to +15.2 kg. Among those that gained weight (Table 4), the average weight gain was 3.0 kg (6.6 lbs), with males gaining an average of 4.1 kg (9.0 lbs) and females gaining an average of 2.6 kg (5.7 lbs). No change in weight was observed in 1% of the sample, and weight loss was observed in 20% of the sample. Among those that lost weight, the average weight lost was 1.7 kg (3.7 lbs), with males losing an average of 3.2 kg (7.1 lbs) and females losing an average of 1.5 kg (3.3 lbs).

Table 3. Physical characteristics and body composition data of male and female University students over the first academic year.

Males (n = 71) Females (n = 203)	Pre	Post	*Sig.
Weight (kg)	**65.1 ± 12.7**	**67.1 ± 13.8**	**<0.001**
Males	76.4 ± 11.2	80.0 ± 13.2	<0.001
Females	61.6 ± 11.2	63.3 ± 11.6	<0.001
Height (cm)	**167.9 ± 8.8**	**167.7 ± 8.9**	**0.58**
Males	178.6 ± 7.5	178.5 ± 7.1	0.49
Females	164.5 ± 6.3	164.4 ± 6.4	0.98
Waist circumference (cm)	**78.9 ± 16.3**	**80.4 ± 11.5**	**<0.001**
Males	81.7 ± 10.7	84.2 ± 15.3	<0.001
Females	78.5 ± 17.7	79.3 ± 9.6	<0.001
Hip circumference (cm)	**96.8 ± 10.0**	**97.9 ± 8.7**	**<0.001**
Males	99.0 ± 6.9	100.6 ± 7.7	0.009
Females	96.1 ± 10.7	97.1 ± 8.8	0.003
BMI (kg/m2)	**23.1 ± 4.4**	**23.9 ± 3.9**	**<0.001**
Males	24.1 ± 3.1	25.2 ± 3.5	<0.001
Females	22.7 ± 4.7	23.5 ± 4.0	<0.001
Body Fat (%)	**22.6 ± 7.8**	**23.3 ± 7.7**	**0.001**
Males	12.9 ± 5.2	12.8 ± 4.6	0.79
Females	25.5 ± 6.0	26.7 ± 5.2	<0.001
LBM (kg)	**50.7 ± 12.4**	**51.8 ± 13.0**	**<0.001**
Males	66.7 ± 9.2	69.7 ± 9.5	<0.001
Females	45.7 ± 9.7	46.3 ± 7.8	0.12
FM (kg)	**14.4 ± 7.5**	**15.8 ± 6.6**	**<0.001**
Males	10.1 ± 5.8	10.8 ± 5.3	0.15
Females	15.7 ± 7.3	17.3 ± 6.2	0.001
BMR (kcals)	**1460 ± 315**	**1492 ± 269**	**<0.001**
Males	1780 ± 283	1877 ± 206	<0.001
Females	1355 ± 245	1373 ± 147	0.001

Data are represented as means ± standard deviation.
*Significance was set as $p<0.05$. P values relate to paired sample t-test (post-pre).
BMI = body mass index, LBM = lean body mass, FM = fat mass, BMR = basal metabolic rate.

Table 4. Physical characteristics and body composition data of male and female University students who gained weight during their first academic year.

	Pre	Post	*Sig.
	Males (*n* = 64)		
Weight (kg)	76.6 ± 10.7	80.7 ± 12.1	<0.001
Height (cm)	178.2 ± 6.8	178.4 ± 6.6	0.45
Waist circumference (cm)	81.8 ± 11.0	84.4 ± 15.7	<0.001
Hip circumference (cm)	99.1 ± 6.8	101.1 ± 7.3	0.002
BMI	24.2 ± 3.1	25.4 ± 3.4	<0.001
Body fat %	12.9 ± 5.1	12.8 ± 4.4	0.88
LBM (kg)	66.8 ± 8.9	70.2 ± 9.1	<0.001
FM (kg)	10.0 ± 6.0	10.9 ± 4.9	0.09
BMR (kcals)	1798 ± 283	1888 ±196	<0.001
	Females (*n* = 174)		
Weight (kg)	61.8 ± 11.1	64.4 ± 11.9	<0.001
Height (cm)	164.5 ± 6.3	164.5 ± 6.5	0.61
Waist circumference (cm)	78.2 ± 19.1	79.9 ± 9.8	<0.001
Hip circumference (cm)	96.3 ± 10.3	98.1 ± 8.9	<0.001
BMI (kg/m2)	22.8 ± 3.8	23.9 ± 4.1	<0.001
Body fat %	25.5 ± 5.8	27.1 ± 5.2	<0.001
LBM (kg)	45.7 ± 8.8	46.8 ± 8.3	0.004
FM (kg)	15.9 ± 6.0	18.0 ± 6.4	<0.001
BMR (kcals)	1361 ± 178	1386 ± 149	<0.001

Data are represented as means ± standard deviation.
*Significance was set as $p<0.05$. P values relate to paired sample t-test (post-pre).
BMI = body mass index, LBM = lean body mass, FM = fat mass, BMR = basal metabolic rate.

Changes in anthropometrics and body composition were also examined according to initial BMI status: desirable BMI (<24.9) and overweight BMI (≥ 25.0) (Table 5). Males with a BMI < 24.9 gained an average of 2.6 kg (5.7 lbs), whereas those with BMI ≥ 25.0 gained an average of 5.7 kg (12.6 lbs). Both groups also experienced significant increases in lean body mass and hip circumference. Females with an initial BMI of < 24.9 gained an average of 1.5 kg (3.3 lbs), and those with an initial BMI ≥ 25.0 gained an average of 2.2 kg (4.9 lbs) (Table 6). Both groups experienced significant increases in fat mass and body fat percentage, and the females with an initial BMI of < 24.9 also experienced significant increases in waist and hip circumference and BMR. Average BMI at the beginning of the year was 24.1 for males and 22.7 for females, and increased to 25.2 ($p<0.001$) in males and 23.5 (<0.001) in females.

Table 5. Anthropometrics and body composition based on baseline BMI status**.**

	BMI <24.9			BMI ≥ 25.0		
	Pre	Post	*Sig.	Pre	Post	*Sig.
Males	*n* = 48			*n* =23		
Weight (kg)	72.2 ± 9.4	74.8 ± 9.7	<0.001	85.2 ± 10.5	90.9 ± 12.5	<0.001
Waist circumference (cm)	78.3 ± 9.7	80.6 ± 16.9	0.008	88.6 ± 10.2	91.7 ± 9.2	0.005
Hip circumference (cm)	96.4 ± 5.9	97.4 ± 5.3	0.12	104.6 ± 6.5	107.3 ± 7.8	0.034
BMI (kg/m2)	22.4 ± 1.8	23.4 ± 2.0	<0.001	27.6 ± 2.2	28.8 ± 3.1	0.016
Body fat %	11.3 ± 3.7	11.1 ± 3.4	0.65	16.6 ± 5.8	16.6 ± 4.5	0.98
LBM (kg)	64.1 ± 7.7	66.9 ± 8.2	<0.001	72.1 ± 9.7	75.6 ± 9.6	0.031
FM (kg)	7.8 ± 3.3	8.7 ± 3.6	0.06	14.7 ± 7.5	15.3 ± 5.5	0.67
BMR (kcals)	1749 ± 173	1816 ± 177	<0.001	1904 ± 421	2005 ± 207	0.035
Females	*n* = 181			*n* = 49		
Weight (kg)	58.1 ± 7.2	59.6 ± 7.6	<0.001	74.6±12.5	76.8 ± 13.5	<0.001
Waist circumference (cm)	75.1 ± 17.9	76.2 ± 6.8	0.001	89.1 ± 11.2	90.2 ± 10.6	0.06
Hip circumference (cm)	93.4 ± 5.8	94.3 ± 5.8	0.012	106.3 ± 9.7	107.6 ± 10.4	0.11
BMI (kg/m2)	21.3 ± 2.2	22.1 ± 2.6	<0.001	27.9 ± 6.4	28.5 ± 4.3	0.09
Body fat %	24.2 ± 4.9	25.3 ± 4.5	0.001	30.1 ± 7.1	31.4 ± 4.7	0.040
LBM (kg)	43.8 ± 9.0	44.6 ± 6.2	0.08	52.6 ± 9.3	52.6 ± 10.29	0.99
FM (kg)	13.9 ± 6.9	15.4 ± 4.1	<0.001	22.3 ± 5.7	24.5 ± 6.9	0.024
BMR (kcals)	1315 ± 211	1338 ± 118	<0.001	1506 ± 277	1505 ± 167	0.98

Data are represented as means ± standard deviation.
* Significance was set as $p<0.05$. P values relate to paired sample t-test (post-pre).
BMI = body mass index, LBM = lean body mass, FM = fat mass, BMR = basal metabolic rate.

Table 6. Changes in anthropometrics and body composition based on baseline BMI status**.**

	BMI <24.9 Change	BMI > 25.0 Change	*Sig.
Males	*n* = 48	*n* = 23	
Weight (kg)	2.6 ± 4.9	5.7 ± 4.4	0.004
Waist circumference (cm)	2.3 ± 17.6	3.1 ± 4.8	0.18
Hip circumference (cm)	1.0 ± 4.5	2.7 ± 5.7	0.83
BMI (kg/m2)	1.0 ± 1.5	1.3 ± 2.3	0.011
Body fat %	0.2 ± 2.9	0.0 ± 5.3	0.026
LBM (kg)	2.8 ± 6.2	3.4 ± 11.4	0.027
FM (kg)	0.8 ± 3.0	0.6 ± 6.2	0.001
BMR (Kcals)	67 ± 78	102 ± 432	0.015
Females	*n* = 181	*n* = 49	
Weight (kg)	1.5 ± 2.5	2.2 ± 3.7	0.003
Waist circumference (cm)	1.1 ± 16.9	1.4 ± 5.2	0.60
Hip circumference (cm)	0.9 ± 8.3	1.3 ± 5.5	0.85
BMI (kg/m2)	0.8 ± 1.7	0.5 ± 6.9	0.18
Body fat %	1.0 ± 4.2	1.3 ± 6.2	0.83
LBM (kg)	0.7 ± 8.5	0.0 ± 11.3	0.34
FM (kg)	1.5 ± 6.8	2.2 ± 5.8	0.001
BMR (Kcals)	22 ± 201	28 ± 217	0.022

Data are represented as means ± standard deviation. Change values are calculated as post-pre.

* Significance was set as $p<0.05$. P values relate to independent t-test.

BMI = body mass index, LBM = lean body mass, FM = fat mass, BMR = basal metabolic rate.

Tables 7 and 8, and Tables 9 and 10 describe the changes in anthropometrics and body composition based on living arrangements and type of meal plan, respectively. For both males and females living on campus, significant increases in body weight were seen. Males gained an average of 3.8 kg (8.4 lbs) and females gained an average of 1.9 kg (4.2 lbs) (Table 9). The males experienced significant gains in lean body mass whereas the females experienced significant gains in fat mass. Significant increases in body weight were observed in both males and females regardless of having a meal plan or not. However, males who had a meal plan also experienced increases in waist circumference, hip circumference, BMI and lean body mass. Females with a meal plan experienced significant increases in hip circumference, BMI, body fat percentage, and fat mass.

Table 7. Anthropometrics and body composition based on living arrangements.

	Residence			Student House			Off-Campus with Family		
	Pre	Post	*Sig.	Pre	Post	*Sig.	Pre	Post	*Sig.
Males	*n* = 51			*n* = 5			*n* = 9		
Weight (kg)	76.7 ± 10.9	80.5 ± 12.8	<0.001	78.0 ± 12.7	79.7 ± 13.8	0.033	70.6 ± 12.7	73.5 ± 13.0	0.015
Waist circumference (cm)	81.3 ± 9.1	84.4 ± 8.6	<0.001	83.5 ± 12.4	82.7 ± 9.6	0.570	80.4 ± 9.0	80.1 ± 10.4	0.890
Hip circumference (cm)	99.7 ± 7.1	101.5 ± 7.3	0.017	98.5 ± 6.7	98.8 ± 10.7	0.88	94.9 ± 7.7	95.5 ± 7.2	0.77
Body fat %	13.7 ± 5.2	13.5 ± 4.6	0.001	25.1 ± 4.4	25.9 ± 4.0	0.16	23.7 ± 3.5	24.8 ± 3.9	0.026
BMI (kg/m2)	24.1 ± 3.0	25.1 ± 3.4	0.85	12.5 ± 5.9	12.5 ± 4.6	0.95	9.9 ± 3.8	9.5 ± 3.7	0.74
LBM (kg)	66.1 ± 7.5	69.8 ± 9.2	<0.001	67.6 ± 6.3	69.2 ± 8.0	0.15	63.4 ± 11.0	66.2 ± 10.7	0.013
FM (kg)	10.8 ± 6.1	11.5 ± 5.6	0.35	9.5 ± 7.5	10.5 ± 6.0	0.39	7.0 ± 3.2	7.2 ± 3.7	0.81
BMR	1804 ± 171	1878.5 ± 200	<0.001	1831 ± 128	1867 ± 173	0.16	1739 ± 238	1800 ± 232	0.014
Females	*n* = 148			*n* = 10			*n* = 50		
Weight (kg)	62.7 ± 11.7	64.6 ± 12.3	<0.001	61.2 ± 6.9	63.2 ± 7.8	0.08	58.1 ± 8.2	59.1 ± 8.7	0.006
Waist circumference (cm)	79.1 ± 10.2	80.2 ± 9.9	0.009	77.1 ± 8.0	79.1 ± 7.6	0.24	76.5 ± 9.4	77.3 ± 8.6	0.31
Hip circumference (cm)	96.9 ± 9.0	98.0 ± 9.4	0.001	96.8 ± 5.3	96.2 ± 5.0	0.69	93.0 ± 12.3	95.1 ± 7.9	0.180
Body fat %	25.7 ± 5.6	27.0 ± 5.3	<0.001	24.9 ± 6.4	26.1 ± 7.1	0.1	24.8 ± 4.9	25.5 ± 4.4	0.001
BMI (kg/m2)	23.0 ± 3.9	2.3.7 ± 4.2	0.001	22.4 ± 2.0	23.8 ± 3.0	0.4	21.9 ± 3.1	22.6 ± 3.5	0.21
LBM (kg)	46.2 ± 7.5	46.4 ± 8.2	0.590	45.7 ± 5.7	47.4 ± 7.9	0.27	44.7 ± 8.1	44.4 ± 6.0	0.76
FM (kg)	16.1 ± 5.7	18.1 ± 6.5	<0.001	14.9 ± 5.9	16.8 ± 5.4	0.14	14.7 ± 5.3	15.4 ± 4.2	0.21
BMR	1452 ± 73	1384 ± 151	0.44	1377 ± 136	1407 ± 172	0.45	1317 ± 109	1333 ± 131	0.12

Data are represented as means **±** standard deviation.

* Significance was set as $p<0.05$. P values relate to paired sample t-test (post-pre).

BMI = body mass index, LBM = lean body mass, FM = fat mass, BMR = basal metabolic rate.

Table 8. Changes in anthropometrics and body composition based on living arrangements.

	Residence	Student House	Off-Campus with family	*ANOVA
	Change	Change	Change	
Males	*n* = 51	*n* = 5	*n* = 9	
Weight (kg)	3.8 ± 4.0	1.7 ± 1.6	2.9 ± 3.3	0.40
Waist circumference (cm)	3.1 ± 8.1	0.8 ± 3.5	0.4 ± 5.4	0.08
Hip circumference (cm)	1.8 ± 5.2	0.3 ± 3.7	0.5 ± 5.9	0.70
BMI (kg/m2)	1.0 ± 2.0	0.9 ± 0.9	1.1 ± 1.6	0.97
Body fat %	0.1 ± 4.3	0.0 ± 2.7	0.4 ± 3.8	0.98
LBM (kg)	3.7 ± 7.5	1.6 ± 2.6	2.8 ± 2.7	0.70
FM (kg)	0.6 ± 4.7	1.0 ± 2.1	0.2 ± 3.0	0.95
BMR (kcals)	74 ± 126	36 ± 59	62 ± 58	0.76
Females	*n* = 148	*n* = 10	*n* = 50	
Weight (kg)	1.9 ± 3.0	2.0 ± 3.7	0.9 ± 2.1	0.09
Waist circumference (cm)	0.7 ± 18.4	1.9 ± 4.9	0.8 ± 5.6	0.80
Hip circumference (cm)	1.7 ± 7.2	0.6 ± 5.5	2.1 ± 10.7	0.44
BMI (kg/m2)	0.8 ± 1.9	1.4 ± 2.9	0.7 ± 2.0	0.62
Body fat %	1.3 ± 4.6	1.2 ± 4.3	0.7 ± 4.0	0.74
LBM (kg)	0.3 ± 9.2	1.7 ± 5.0	0.3 ± 7.8	0.65
FM (kg)	1.9 ± 7.8	1.9 ± 4.5	0.7 ± 3.7	0.21
BMR (kcals)	-68 ± 231	30 ± 137	15 ± 167	0.82

Data are represented as means ± standard deviation. Change vales are calculated as post-pre.

* Significance was set as $p<0.05$. P values relate to one-way ANOVA.

BMI = body mass index, LBM = lean body mass, FM = fat mass, BMR = basal metabolic rate.

Table 9. Anthropometrics and body composition based on meal-plan type.

	Meal Plan			No Meal Plan		
	Pre	Post	*Sig.	Pre	Post	*Sig.
Males	*n* = 38			*n* = 27		
Weight (kg)	77.7 ± 10.9	82.2 ± 12.9	<0.001	73.5 ± 11.5	75.7 ± 12.2	0.001
Waist circumference (cm)	82.2 ± 9.2	85.6 ± 9.1	<0.001	80.3 ± 9.3	81.4 ± 8.2	0.370
Hip circumference (cm)	99.6 ± 7.2	102.7 ± 8.1	<0.001	98.1 ± 7.4	97.4 ± 6.3	0.46
BMI (kg/m2)	24.2 ± 3.2	25.5 ± 3.7	<0.001	23.9 ± 3.1	24.5 ± 3.0	0.09
Body fat %	14.0 ± 5.6	14.2 ± 4.8	0.840	11.7 ± 4.3	11.2 ± 3.8	0.4
LBM (kg)	67.0 ± 7.4	70.8 ± 8.7	<0.001	64.2 ± 8.5	67.1 ± 9.8	0.012
FM (kg)	11.5 ± 6.9	12.4 ± 5.7	0.310	8.4 ± 3.8	8.7 ± 3.8	0.67
BMR (kcals)	1811 ± 158	1901 ± 189	<0.001	1779 ± 204	1819 ± 211	0.033
Females	*n* = 123			*n* = 85		
Weight (kg)	63.1 ± 12.1	65.0 ± 12.6	<0.001	59.4 ± 8.5	60.5 ± 9.4	<0.001
Waist circumference (cm)	79.7 ± 10.5	80.7 ± 9.9	0.016	76.6 ± 8.8	77.6 ± 8.7	0.08
Hip circumference (cm)	97.0 ± 9.2	98.3 ± 9.4	0.001	94.3 ± 10.6	95.7 ± 8.0	0.15
BMI (kg/m2)	23.1 ± 4.0	24.0 ± 4.1	<0.001	22.1 ± 3.1	22.8 ± 3.6	0.001
Body fat %	25.8 ± 5.5	27.3 ± 5.3	<0.001	24.8 ± 5.5	25.6 ± 4.9	0.2
LBM (kg)	46.3 ± 7.7	46.7 ± 8.5	0.690	45.0 ± 7.4	45.2 ± 6.9	0.86
FM (kg)	16.1 ± 5.8	18.5 ± 6.7	<0.001	15.2 ± 5.3	15.8 ± 4.7	0.140
BMR (kcals)	1473 ± 175	1391 ± 150	0.44	1334 ± 123	1347 ± 143	0.15

Data are represented as means ± standard deviation.
* Significance was set as $p<0.05$. P values relate to paired samples t-test (post-pre).
BMI = body mass index, LBM = lean body mass, FM = fat mass, BMR = basal metabolic rate.

Table 10. Changes in anthropometrics and body composition based on meal-plan type.

	Meal Plan	No Meal Plan	* Sig.
Males	*n* = 38	*n* = 27	
Weight (kg)	4.5 ± 3.8	2.1 ± 3.1	0.38
Waist circumference (cm)	3.4 ± 5.2	1.0 ± 10.5	0.86
Hip circumference (cm)	3.1 ± 4.3	- 0.8 ± 5.2	0.07
BMI (kg/m2)	1.3 ± 2.0	0.6 ± 1.6	0.44
Body fat %	0.1 ± 4.5	- 0.5 ± 3.2	0.23
LBM (kg)	3.8 ± 7.3	2.9 ± 5.5	0.67
FM (kg)	0.8 ± 5.0	0.3 ± 3.5	0.27
BMR (kcals)	90 ± 123	40 ± 94	0.48
Females	*n* = 123	*n* = 85	
Weight (kg)	2.0 ± 2.9	1.2 ± 2.6	0.27
Waist circumference (cm)	1.0 ± 19.8	1.1 ± 7.2	0.17
Hip circumference (cm)	1.3 ± 19.8	1.3 ± 8.6	0.20
BMI (kg/m2)	0.9 ± 1.9	0.7 ± 2.0	0.29
Body fat %	1.5 ± 3.9	0.7 ± 5.2	0.14
LBM (kg)	0.2 ± 10.0	0.1 ± 6.7	0.94
FM (kg)	2.3 ± 8.5	0.6 ± 3.5	0.22
BMR (kcals)	- 82 ± 224	40 ± 198	0.21

Data are represented as means **±** standard deviation. Change values are calculated as post-pre.
* Significance was set as $p<0.05$. P values relate to independent t-test.
BMI = body mass index, LBM = lean body mass, FM = fat mass, BMR = basal metabolic rate.

4.3 Physical Activity

4.3.1 Physical Activity Output

Table 11 describes the habitual physical activity patterns of the students over their first year of university, as assessed by the 2014 Block Food Frequency and Activity Questionnaire (FFAQ). We observed significant reductions in energy expenditure, light and moderate activity minutes, and MET minutes in males over the year. The females followed a similar pattern, with significant reductions in energy expenditure, light, moderate, and vigorous activity minutes, and MET minutes over the year.

Table 11. Physical activity output per week.

		Pre	Post	*Sig.
Males	Energy expenditure (kcals)	1443 ± 974.4	1051 ± 766.9	0.002
	Light Activity Minutes	107 ± 83.4	71 ± 71.7	0.002
	Moderate Activity Minutes	67 ± 73.1	31 ± 40.8	<0.001
	Vigorous Activity Minutes	80 ± 58.8	67 ± 59.3	0.10
	MET Minutes	1067 ± 653	750 ± 519	<0.001
Females	Energy expenditure (kcals)	1099 ± 802.7	512 ± 427.2	<0.001
	Light Minutes	134 ± 85.5	55 ± 57.1	<0.001
	Moderate Minutes	87 ± 99.7	28 ± 37.0	<0.001
	Vigorous Minutes	52 ± 55.7	33 ± 35.8	<0.001
	MET Minutes	1010 ± 654	461 ± 380	<0.001

Data are represented as means ± standard deviation.
* Significance was set as $p<0.05$. P values relate to paired sample t-test (post-pre).
MET = metabolic equivalent for task.

4.3.2 Time Spent Doing Physical Activity

Figures 5 and 6 depict the amount of free time spend being physically active in high school compared to university, among males and females. No significant differences were observed among males. Among females, significant differences were observed for free time spent doing activities involving little physical effort (p= 0.007), physical activity during free time 1-2 times per week (p= 0.014), physical activity during free time 3-4 times per week (p= 0.014), and for physical activity during free time seven or more times per week (p= 0.010).

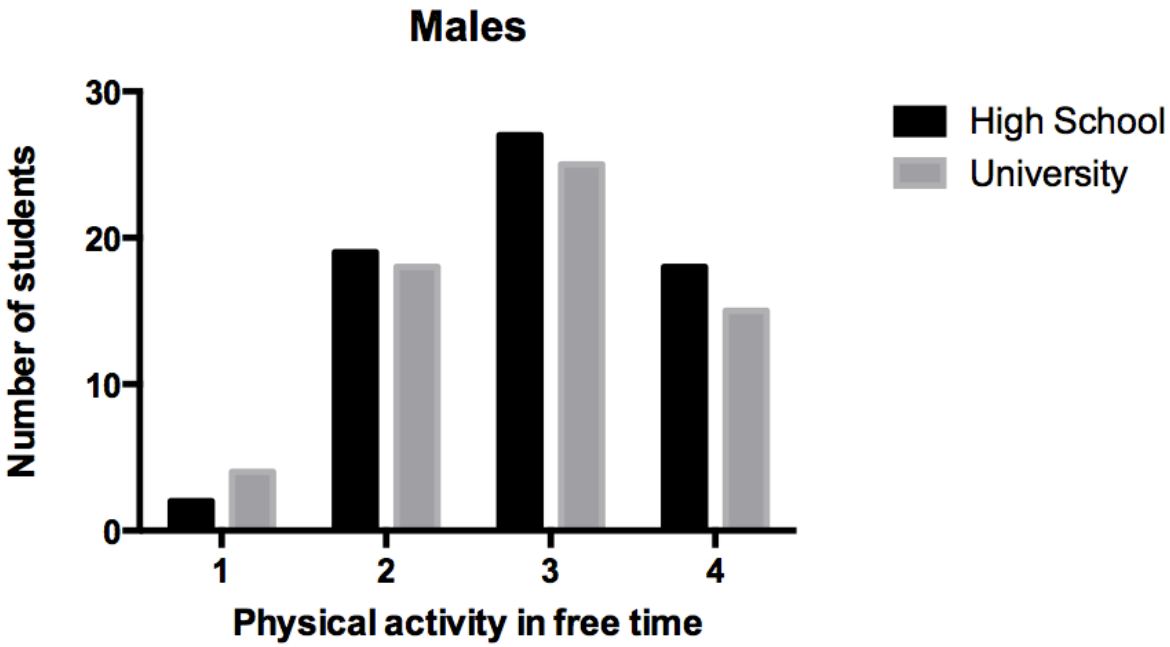


Figure 5. Amount of free time spent being physically active in high school compared to university, among males.
1 = All or most of my free time was spent doing things that involve little physical effort.
2 = I sometimes (1-2 times per week) was physically active in my free time.
3 = I often (3-4 times per week) was physically active in my free time.
4 = I very often (7+ timer per week) was physically active in my free time.

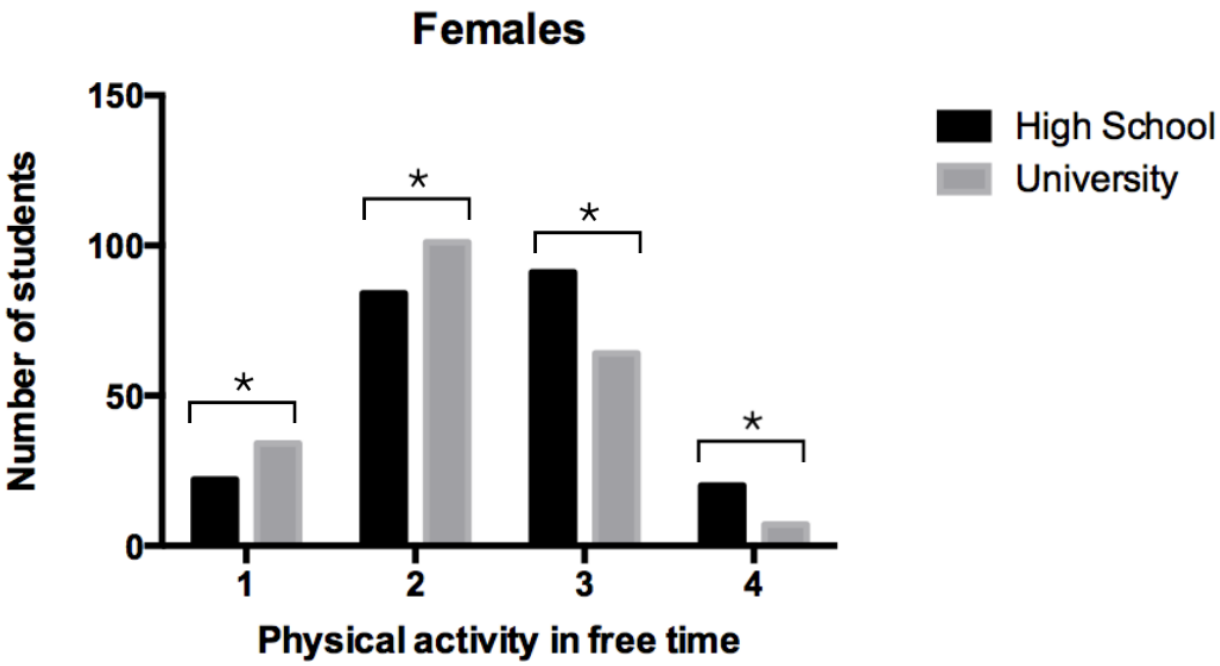


Figure 6. Amount of free time spent being physical active in high school compared to university, among females.
1 = All or most of my free time was spent doing things that involve little physical effort.
2 = I sometimes (1-2 times per week) was physically active in my free time.
3 = I often (3-4 times per week) was physically active in my free time.
4 = I very often (7+ timer per week) was physically active in my free time.
*Indicates a significant difference ($p<0.05$) between high school and university (grey and black bars) for the same question.

4.3.3 Level of Physical Activity

Figures 7 and 8 depict the levels of physical activity that students engaged in, in high school compared to university, among males and females. The questionnaire examined activities such as physical education classes, intramurals (non-competitive school sports), competitive sports (both in and out of school competitive sports), recreational sports (out of school recreational sports), and other activities (including: fitness classes, weightlifting, martial arts, etc.). Significant differences were detected in physical education classes ($p<0.001$), competitive sports ($p<0.001$), and recreational

sports (p<0.001) during university among males, indicating less participation. No changes were seen in intramural activities (p= 0.66), and the number of males engaging in other activities increased significantly (p= 0.020). Similar patterns of significance were observed among the female participants. Significant differences were observed for engagement in physical education classes (p<0.001), competitive sports (p<0.001), recreational sports (p<0.001), and other activities (p<0.001) indicating less participation. No differences were observed for participation in intramural activities (p= 0.64).

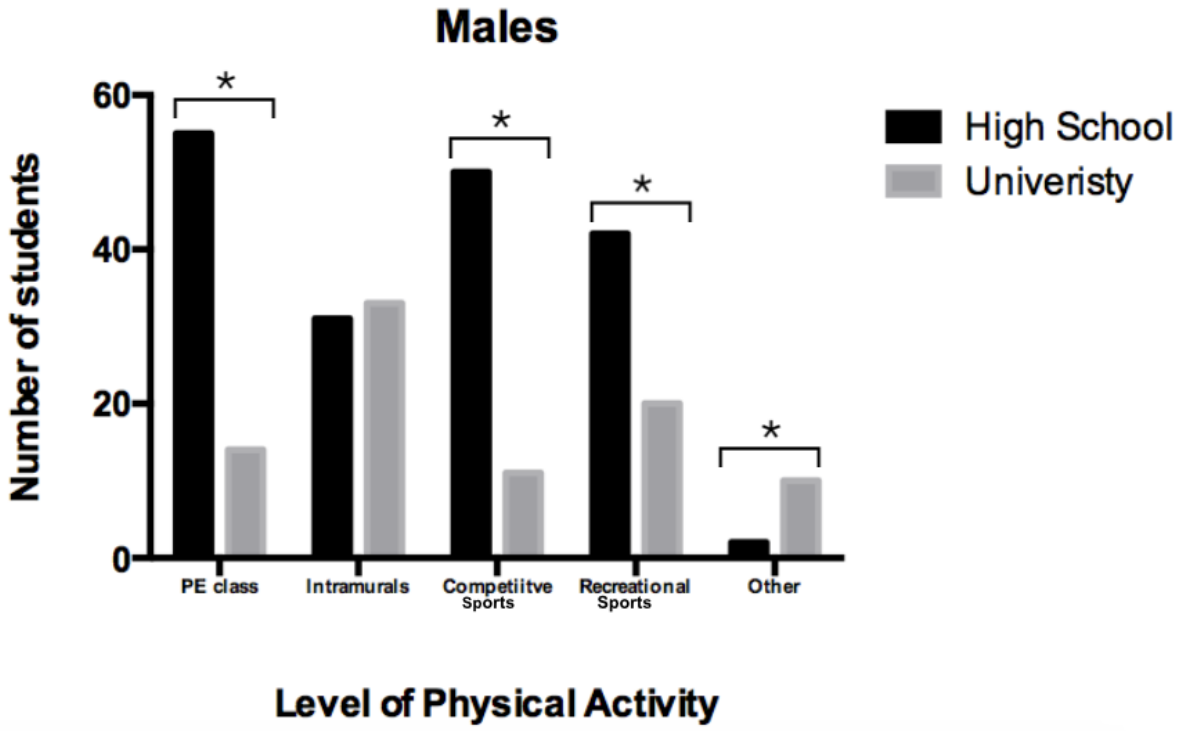


Figure 7. Number of male students engaged in organized sport activities during high school versus university.
* Indicates a significant difference (p<0.05) between high school and university (grey and black bars) for the same number of sports.

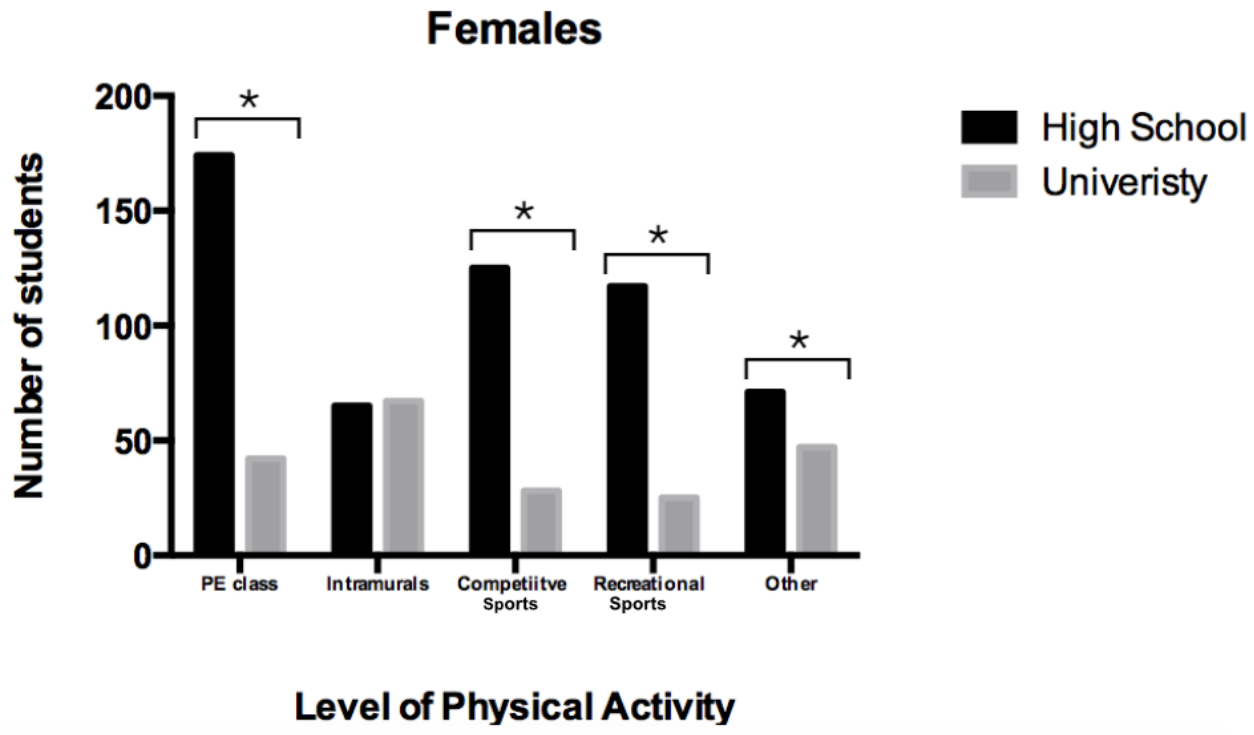


Figure 8. Number of male students engaged in organized sport activities during high school versus university.
* Indicates a significant difference ($p<0.05$) between high school and university (grey and black bars) for the same number of sports.

4.3.4 Organized Sport Frequency

Figures 9 and 10 display the changes in the frequency of engagement in organized sports during high school versus university, among males and females, respectively. Significantly more males ($p<0.001$) and females ($p<0.001$) engaged in two or less organized sports during university compared to high school, where they spent more time engaged in organized sports. Significant differences were detected in males, who engaged in 3-5 organized sports ($p= 0.049$) while in University compared to twelve or organized sports in high school ($p= 0.024$). This difference clearly indicates more sport participation in high school than in university. While the number of males engaging in 6-8 and 9-11 organized sports decreased from high school to university the changes were not

significant (p= 0.48, and p= 0.32, respectively). Significant differences were also detected in females engaging in 3-5 (p=0.005), 6-8 (p<0.001), and twelve or more (p=0.025) organized sports, indicating less participation during university. The number of females engaging 9-11 organized sports decreased, however the change was not significant (p=0.16)

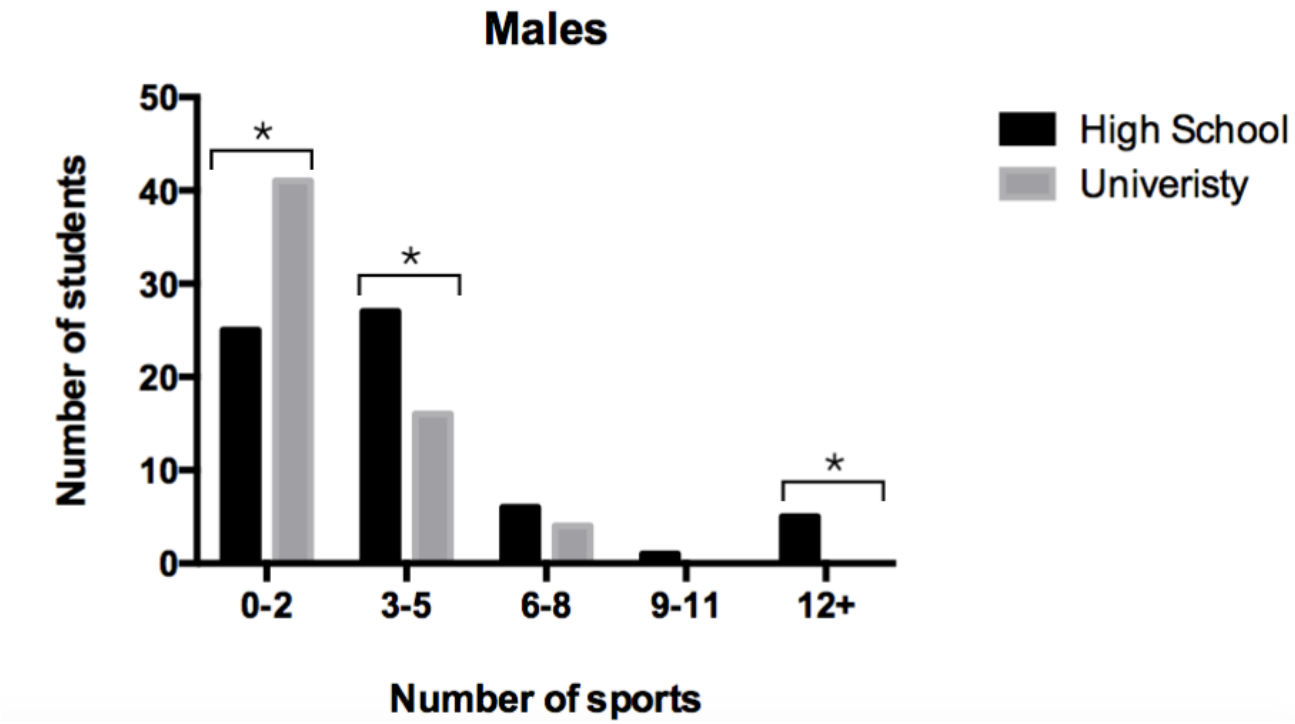


Figure 9. Frequency of engagement in sports that were organized by the school in high school compared to university, among males.
* indicates a significant difference (p<0.05) between high school and university (grey and black bars) for the same number of sports.

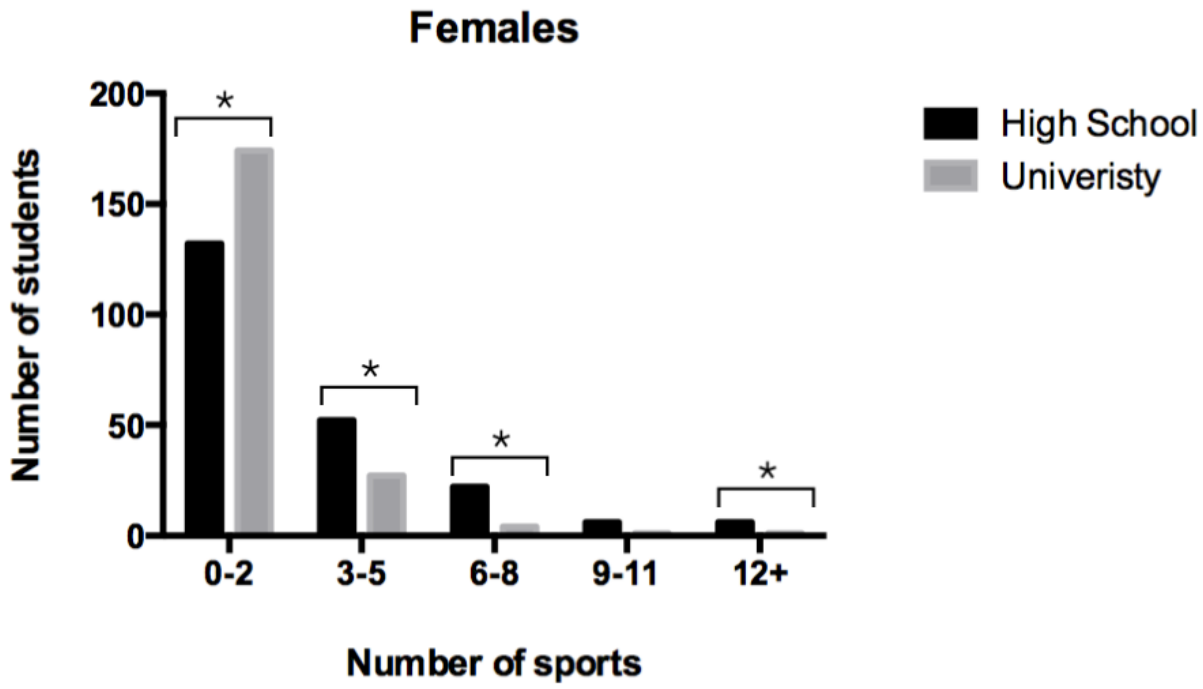


Figure 10. Frequency of engagement in sports that were organized by the school in high school compared to university, among females.
* indicates a significant difference ($p<0.05$) between high school and university (grey and black bars) for the same number of sports.

4.3.5 Determinants of Physical Activity

Table 12 depicts the intrapersonal factors (including: shyness, stress, perceived self-skill, past bad experiences, lack of interest and fear of failure), interpersonal factors (including: lack of friends, peer influence, gender, ethnic background, perceived body image, and age) and structural factors (including: employment, homework, class schedule, income, distance of residence, lack of advertising, available free time, transportation, participation fees, sports offered, and overcrowded facilities) that affect participants' involvement in physical activity during university. Students rated the extent to which each factor was a barrier to their participation in physical activity, based on a 5-point Likert scale (1- not a barrier, 5 – strong barrier). While significant increases in the

extent of each barrier were seen, both males and females regarded interpersonal factors as being the strongest barriers to physical activity during first year university.

Table 12. Participation barriers that affect participants' involvement in physical activity at university to a great extent.

	Pre	Post	*Sig.
	Males (n = 48)		
Intrapersonal	2.1 ± 0.8	3.3 ± 1.2	<0.001
Interpersonal	1.7 ± 0.7	4.3 ± 0.9	<0.001
Structural	2.3 ± 0.6	3.5 ± 0.9	<0.001
	Females (n = 161)		
Intrapersonal	2.6 ± 0.9	3.1 ± 1.0	<0.001
Interpersonal	1.8 ± 0.7	4.0 ± 1.2	<0.001
Structural	2.3 ± 0.8	3.6 ± 1.0	<0.001

Data are represented as means ± standard deviation.
* Significance was set as $p<0.05$. P values relate to paired samples t-test (post-pre).
BMI = body mass index, LBM = lean body mass, FM = fat mass, BMR = basal metabolic rate.

4.3.6 Physical Activity Frequency

Table 13 examines the changes in the frequency of engagement in different types of physical activities that students engage in, in high school compared to university, among males and females. Endurance sports include: biking, cross-country skiing, floor hockey, jogging/running, ice skating, in-line skating, skipping, street hockey, skateboarding, tag, and walking for exercise. Team sports include: badminton, baseball, basketball, football, ice hockey, rowing, swimming, soccer and volleyball. Fitness activities include: aerobics, dance, martial arts, and yoga. The frequency of each activity was assessed using a 6-point Likert scale where 1 = no engagement, and 6 = played the

sport 10+ times per month. Among males, the frequency of engagement in all activity types declined, however only the reduction in team sports was significant (p=0.003). Females experienced significant reductions in team sport participation (p< 0.001) and in endurance sport participation (p=0.001). An increase in fitness activities was also observed, however the change was not significant.

Table 13. Types of sports participated in.

	Pre	Post	*Sig.
	Males (n = 59)		
Endurance	2.3 ± 1.1	2.0 ± 0.6	0.051
Team Sports	2.3 ± 1.1	1.9 ± 0.7	0.003
Fitness	1.7± 1.0	1.5 ± 0.6	0.32
	Females (n = 208)		
Endurance	2.1 ± 0.8	1.9 ± 0.7	0.001
Team Sports	2.0 ± 1.0	1.4 ± 0.6	<0.001
Fitness	2.0 ± 1.0	2.1 ± 1.1	0.09

Data are represented as means ± standard deviation.
* Significance was set as p<0.05. P values relate to paired samples t-test (post-pre).
BMI = body mass index, LBM = lean body mass, FM = fat mass, BMR = basal metabolic rate.

4.4 Physical Activity, Weight and Body Composition

Table 14 presents the changes in anthropometrics and body composition based on those who achieved CSEPs recommendation of 150 minutes of physical activity per week and those who did not. Significant increases in weight were observed among males and females regardless of the activity levels they achieved. Only 24.5% of the male

participants and 13.9% of the female participants engaged in the recommended 150 minutes of physical activity per week.

Table 14. Anthropometric and body composition measurements based on weekly minutes of moderate and vigorous physical activity (< / > 150 minutes).

	< 150 minutes		*Sig.	> 150 minutes		*Sig.
	Pre	Post		Pre	Post	
Males	n = 57			n = 14		
Weight (kg)	76.5 ± 11.1	80.1 ± 13.0	<0.001	76.2 ± 13.3	79.6 ± 14.5	<0.001
Waist circumference (cm)	81.9 ± 8.7	84.6 ± 8.9	0.001	81.0 ± 12.4	83.0 ± 10.2	0.17
Hip circumference (cm)	98.8 ± 6.9	100.7 ± 7.8	0.008	99.9 ± 8.6	100.4 ± 7.7	0.71
BMI (kg/m2)	24.1 ± 3.1	25.1 ± 3.5	<0.001	24.1 ± 3.4	25.2 ± 3.5	0.004
Body fat %	13.3 ± 5.3	13.2 ± 4.5	0.83	11.6 ± 4.2	11.4 ± 4.5	0.89
LBM (kg)	66.6 ± 8.1	69.6 ± 9.5	<0.001	67.4 ± 10.6	70.1 ± 10.1	0.01
FM (kg)	10.4 ± 6.2	11.2 ± 5.3	0.24	8.8 ± 4.7	9.6 ± 5.4	0.32
BMR	1795 ± 189	1875 ± 220	<0.001	1816 ± 222	1886 ± 218	0.003
Females	n = 202			n = 28		
Weight (kg)	61.8 ± 11.1	63.4 ± 11.8	<0.001	60.6 ± 9.1	62.6 ± 9.7	<0.001
Waist circumference (cm)	78.2 ± 9.9	79.4 ± 9.7	<0.001	77.1 ± 9.0	78.1 ± 9.0	0.29
Hip circumference (cm)	96.1 ± 8.6	97.1 ± 9.3	0.003	96.3 ± 8.8	97.0 ± 7.5	0.56
BMI (kg/m2)	22.7 ± 3.7	23.4 ± 4.0	<0.001	22.8 ± 3.6	24.1 ± 3.7	0.001
Body fat %	25.4 ± 5.3	26.5 ± 5.2	<0.001	26.4 ± 5.1	26.7 ± 4.9	0.59
LBM (kg)	45.9 ± 8.1	46.3 ± 7.3	0.38	44.3 ± 4.2	46.4 ± 5.7	0.003
FM (kg)	15.7 ± 6.0	17.3 ± 6.2	<0.001	16.1 ± 5.9	17.6 ± 5.5	0.22
BMR	1359 ± 150	1374 ± 150	0.012	1329 ± 91	1368 ± 123	0.011

Data are represented as means ± standard deviation.
* Significance was set as $p<0.05$. P values relate to paired samples t-test (post-pre).
BMI = body mass index, LBM = lean body mass, FM = fat mass, BMR = basal metabolic rate.

Table 15. Changes in anthropometric and body composition measurements based on weekly minutes of moderate and vigorous physical activity (< / > 150 minutes).

	< 150 minutes	> 150 minutes	*Sig
Males (*n* = 71)			
Weight (kg)	3.7 ± 8.5	3.4 ± 2.3	0.16
Waist circumference (cm)	2.7 ± 9.2	2.1 ± 29.4	0.94
Hip circumference (cm)	1.8 ± 6.1	0.4 ± 4.2	0.45
BMI (kg/m2)	1.0 ± 5.5	1.1 ± 3.1	0.28
Body fat %	- 0.1 ± 2.4	- 0.1 ± 1.2	0.52
LBM (kg)	3.1 ± 7.8	2.7 ± 12.1	0.40
FM (kg)	0.7 ± 5.8	0.8 ± 2.9	0.27
BMR (kcals)	80 ± 292	70 ± 73	0.32
Females (*n* = 230)			
Weight (kg)	1.6 ± 4.4	2.0 ± 2.1	0.11
Waist circumference (cm)	1.2 ± 15.9	1.0 ± 9.9	0.67
Hip circumference (cm)	1.0 ± 8.3	0.6 ± 5.7	0.67
BMI (kg/m2)	0.7 ± 4.8	1.4 ± 3.7	0.67
Body fat %	1.1 ±3.8	0.4 ± 1.9	0.79
LBM (kg)	0.3 ± 9.3	2.1 ± 10.9	0.68
FM (kg)	1.7 ±7.0	1.4 ± 3.7	0.36
BMR (kcals)	14 ± 225	39 ± 76	0.97

Data are represented as means ± standard deviation. Change values are calculated as post-pre.

* Significance was set as $p<0.05$. P values relate to independent samples t-test.

BMI = body mass index, LBM = lean body mass, FM = fat mass, BMR = basal metabolic rate.

Table 16 examines the changes in physical activity among students studying Kinesiology compared to those in other programs. Males experienced significant reductions in all physical activity measures, except for vigorous activity. Females, however, experienced significant reductions in all physical activity measures over the year.

Table 16. Physical activity output among Kinesiology students.

	Kinesiology Students			Other Programs		
	Pre	Post	*Sig.	Pre	Post	*Sig.
Males	*n* = 19			*n* = 52		
Energy Expenditure (kcals)	1494 ± 990.9	937 ± 592.3	0.07	1458 ± 960.7	1079 ± 862.3	0.007
Light activity minutes	94.4 ± 80.0	58.9 ± 66.0	0.45	113.6 ± 85.6	77.2 ± 73.1	0.006
Moderate activity minutes	56.3 ± 70.8	23.9 ± 37.0	0.11	69.0 ± 71.9	33.1 ± 42.2	<0.001
Vigorous activity minutes	99.3 ± 59.0	64.0 ± 45.8	0.08	75.4 ± 53.5	66.6 ± 63.7	0.24
MET minutes	1123 ± 718	664 ± 364	0.038	1059 ± 623	664 ± 364	0.002
Females	*n* = 47			*n* = 183		
Energy Expenditure (kcals)	1050 ± 671.5	487.8 ± 443.0	<0.001	1106 ± 831.6	513.9 ± 428.9	<0.001
Light activity minutes	127.1 ± 84.1	49.7 ± 58.8	<0.001	134.9 ± 86.1	55.4 ± 57.0	<0.001
Moderate activity minutes	71.2 ± 75.4	21.0 ± 24.5	<0.001	91.8 ± 105.1	29.5 ± 39.4	<0.001
Vigorous activity minutes	53.4 ± 51.9	34.4 ± 33.0	0.007	51.2 ± 57.7	32.8 ± 37.2	<0.001
MET minutes	959 ± 574	439 ± 375	<0.001	1019 ± 676	470 ± 385	<0.001

Data are represented as means ± standard deviation.
* Significance was set as $p<0.05$. P values relate to paired samples t-test (post-pre).
MET = metabolic equivalent for task.

Table 17. Changes in physical activity output among Kinesiology students.

	Kinesiology Students	Other Programs	*Sig.
Males	n = 19	n = 52	
Energy Expenditure (kcals)	-557 ± 1215.4	-379 ± 969.4	0.26
Light activity minutes	-35.5 ± 102.8	-36.5 ± 91.7	0.56
Moderate activity minutes	-32.4 ± 85.0	-35.9 ± 68.1	0.47
Vigorous activity minutes	-35.3 ± 83.1	-8.8 ± 53.8	0.5
MET minutes	-460 ± 89	-291 ± 643	0.14
Females	n = 47	n = 183	
Energy Expenditure (kcals)	-562 ±597.6	-592 ± 783.9	0.28
Light activity minutes	-77.4 ± 99.2	-79.6 ± 90.1	0.56
Moderate activity minutes	-50.2 ± 72.3	-62.3 ± 101.6	0.11
Vigorous activity minutes	-19.1 ± 53.0	-18.4 ± 53.4	0.89
MET minutes	-520 ± 550	-549 ± 645	0.34

Data are represented as means ± standard deviation.
* Significance was set as $p<0.05$. Change values are calculated as post-pre.
MET = metabolic equivalent for task.

CHAPTER 5: Discussion

5.1 Introduction

This thesis aimed to identify/characterize the changes in physical activity behaviours among first year students as they transition from high school to university, and during their first year of university, and to assess how these changes are related to body weight and body composition. It was hypothesized that (1) changes in weight and body composition would be observed across the sample favouring increases in fat mass and decreases in lean mass; (2) there would be a decrease in both the quality (intensity and type) and quantity (frequency and time) of physical activity that students engage in; and (3) reductions in physical activity would be associated with increases in both fat mass and body fat percentage. The main findings of the study are as follows: (1) Body weight increased significantly over the first year university, due to an increase in lean mass in males and by an increases in fat mass in females. (2) Significant reductions in the quality and quantity of physical activity were observed in both males and females. (3) Reductions in energy expenditure, MET minutes, light, moderate, and vigorous activity minutes were observed in both males and females, however these changes were not associated with changes in weight and body composition.

5.2 Physical Characteristics and Body Composition

While the assumption that first year students will gain the ‘Freshman Fifteen’ (6.7 kg) during their first year at university is supported by popular culture, there exists limited scientific evidence to support this claim [38]. The current study provides evidence to further refute this idea. Consistent with previous research, we observed that most

(79%), but not all first year students gained a significant amount of weight during their first year in university. Average weight gain in our study was 2.0 kg (4.4 lbs), which is similar to the weight gain cited in many recent studies [38]. Although this may not seem to be a considerable change in weight, it is in fact substantial, particularly when compared to the average weight gain of slightly less than 1.0 kg observed by the national sample of young adults who participated in the Canadian Health Measures Survey [17].

The results from this thesis demonstrate that males gained an average of 3.6 kg (7.9 lbs) and females gained an average of 1.7 kg (3.7 lbs) over the academic year. This same pattern was apparent among the subgroup of students that gained weight. Among the students that gained weight, males gained an average of 4.1 kg (9.0 lbs) and females gained an average of 2.6 kg (5.7 lbs). Our observation that males gain more weight than females over the academic year is supported by the existing literature [38].

These results contribute to our knowledge about weight gain among first year students in several ways. First, they show that significant weight gain occurs over the year among both males and females. Second, this weight gain may be consequential to health judging by the changes in waist and hip circumference and physical activity. Several studies have reported that students who demonstrate patterns of weight gain in university are more likely to gain weight later in life, and are at a higher risk for being overweight and obese later in life [24]. These changes in weight may be associated with no longer participating in organized sports, having less leisure time than while in high school, or making less of an effort to stay physically active.

Similar to body weight, our results indicated a significant increase in BMI over the academic year in both males and females. The average BMI for males increased from

24.1 to 25.2 (kg/m^2), and the average BMI for females increased from 22.7 to 23.5 (kg/m^2). As no changes in height were observed among males or females over the course of the year, the increases in BMI are therefore reflective of weight gain. Importantly, we also found that 13% of males and 11% of females experienced a shift from the desired BMI category to the overweight/obese BMI category over the year. This was similar to the shifts previously reported [3]. However, BMI is not necessarily an accurate indicator of health as it does not account for body composition. It is possible that the shift experienced by the males was driven by their increase in lean mass.

Body fat percentage increased significantly across the sample by an average of 0.7% which is consistent with similar studies [36]. When separating our data by sex we found that body fat percentage decreased by 0.1% in males, and it increased by 1.2% in females over the academic year. The increase in body fat percentage in females is consistent with the literature [27]. However, the decrease in body fat percentage among males is novel. Previous studies have reported that males experience increases in body fat percentage; + 1.2% measured by BIA [27], + 0.7% measured by BIA [57] due to increases in caloric intake and decreases in physical activity, respectively.

In our study, body composition was measured with both BIA and BMX. Both devices have been shown to correlate well with each other [46]. However, the BIA device is sensitive to the hydration level of the body tissues, and hydration status of the subjects is the main limitation to this device [51]. We attempted to control for hydration by asking our participants to refrain from consuming water before their lab visit, and by providing them with 500mL of water to consume prior to the BIA analysis. However, we observed variability in the extra-cellular water (ECW) and total body water (TBW) volumes,

indicating that the participants' hydration levels were different pre to post. For this reason we chose to report only the results from the BMX device as it is not affected by hydration status, allowing for greater accuracy in its results [57].

Significant changes were observed in body composition over the year. Fat mass and lean body mass increased significantly across the sample. When separating the effects by sex we observed that the increase in lean body mass was not significant in females, and that the increase in fat mass was not significant in males, leading us to the conclusion that the weight gain in males was primarily driven by increases in lean body mass and that the weight gain in females was primarily driven by increases in fat mass. This trend was also apparent among the subgroup of students who gained weight over the academic year. These males also experienced significant increases in lean body mass. The females who gained weight experienced significant increases in both lean and fat mass, however the increase in lean mass was small compared to the increase in fat mass.

Understanding how students are gaining weight (through fat mass or lean body mass) will allow future researchers to develop effective strategies to combat this health issue. However, the majority of studies examining the phenomenon of first year weight gain have not incorporated measures of body composition. While a number of recent studies have examined changes in body fat percentage, none have used the BMX device [2]. The inclusion of body composition analysis in our study allowed us to gain further insight on the changes in weight across the sample, and to observe the differences among sex. The observation that weight gain in females is mainly due to significant increases in fat mass is supported by the literature [57]. In fact, similar results were found by Jung et al. (2008) and by Edmonds et al. (2008), who found that female participants who gained

weight over the year also experienced significant increases in fat mass [58]. However, our observation that weight gain in males was due to significant increases in lean mass, as opposed to increases to fat mass, is novel. It is important to note that this weight gain among males was healthy weight gain. Without analyzing for body composition we would have missed this and thought their weight gain was unhealthy. The observed increase in lean mass, as well as the observed decrease in body fat percentage, might be related to the type of physical activity that the male participants engaged in. While light and moderate physical activity minutes decreased among males, their vigorous physical activity minutes remained stable over the year. Vigorous intensity activities have been shown to increase lean mass and reduce fat mass [59]. In addition, it was observed that males engaged in more weight lifting activities during first year university than during high school. Weight training is also known to lead to increases in lean mass and decreases in fat mass [6].

Waist and hip circumference also significantly increased by 2.5cm and 1.6cm respectively in males, and by 0.8cm and 1.0cm respectively in females. Only two studies have examined waist and hip circumferences during the first year of university. Pullman et al. (2009) found larger but significant increases in waist and hip circumference in 108 males over 8 months [60], and Morrow et al. (2006) found smaller but significant increases in 137 females over 8 months [61]. Our findings are of concern as it has been established that increased waist and hip circumference are predictors for many non-communicable diseases, including type 2 diabetes and cardiovascular disease [62].

Changes in body composition and anthropometrics were also examined based on initial BMI status, i.e. when the participants began university. Males who entered

university with a normal BMI (<24.9) experienced an average weight gain of 2.6 kg, and those who entered with an overweight BMI (>25.0) experienced an average weight gain of 5.7 kg. These changes in weight were significant from both the beginning to the end of the year, and from each other, suggesting that males will experience weight gain regardless of their initial BMI status, however those with initially overweight BMIs will gain greater amounts of weight. Interestingly, lean body mass significantly increased among both groups, further supporting our observation that weight gain in males in this study is primarily driven by increases in lean body mass. A similar pattern of weight gain was observed among the females. Females who entered university with a normal BMI experienced an average weight gain of 1.5 kg, and those who entered with an overweight BMI experienced an average weight gain of 2.2 kg. These changes in weight were also significant from both the beginning to the end of the year, and from each other, suggesting that females will experience weight gain regardless of their initial BMI status, however those with initially overweight BMIs will gain greater amounts of weight. Both groups of females also experienced significant increases in fat mass, further supporting our observation that weight gain in females is primarily driven by increases in fat mass. The BMI data are supported by the existing literature. Research has demonstrated that students who enter university with BMIs considered overweight or obese are likely to remain overweight or obese throughout their university years [63]. Additionally, initial BMI has been found to be associated with weight gain over the year, suggesting that those with initially high BMIs are at a greater risk of weight gain [1].

When examining changes in weight based on living arrangements, our results show that males living in residence gained an average of 3.8 kg, those living off-campus

in a student house gained 1.7 kg, and those living off-campus with family gained an average of 2.9 kg. While males living in residence gained more than those living off-campus in a student house or with family, the weight changes based on living arrangements were not significantly different from each other. Among females, those living in residence gained an average of 1.9 kg, those living off-campus in a student house gained 2.0 kg, and those living off-campus with family gained 0.9 kg. Similar to the males, weight changes based on living arrangements were not significantly different between groups for females, however those living in residence gained more weight than those living off campus with family members. It is however important to consider the small sample size of both the males and females living off-campus in student houses (n = 5) and (n = 10) respectively, and note that these results might not be representative.

A separate analysis comparing weight gain between those living in residence to those living off-campus in either a student house or with family was also conducted. It was observed that while the students living on campus gained more weight, it was not significantly different from the weight gained by students living off-campus. This outcome was a surprise as it has been reported that students living on campus tend to gain significantly more weight than those living off-campus. Anderson et al. (2009) reported that students living in residence gained more weight as they had greater accessibility to food, leading them to more frequent snacking [1]. Additionally, Levitsky et al. (2004) found that students living in residence tended to consume more evening snacks and high-fat foods leading them to gain more weight [64]. However, 71% of the participants in this study lived on campus, thus creating unequal group sizes between living arrangements which could explain the non-significant results. Nevertheless, we did see that the students

living on campus gained weight but this gain was not significantly different from those living off-campus.

Similar results were observed between weight and body composition change and being on a meal-plan or having no set meal-plan. Despite observing larger increases in weight among both males and females that were on a university meal-plan, no significant differences were observed. This finding contrasts the prevalent finding that students with a meal-plan gain more weight [64]. Campus dining halls are often set up in a manner similar to an all-you-can- eat buffet, making it easier for students to consume more food than they should, thus leading to weight gain. In addition, it has been cited that first year students tend to make poor nutritional choices in these buffet-style dining halls, favouring foods that are energy-dense and high in fat [64]. However, at Brock, the residence cafeterias are set up in a way that students must pay for each food item separately. It is plausible that this manner of purchasing food prevented the students from consuming as much food as they would have if they were eating in dining halls with all-you-can-eat buffets.

5.3 Physical Activity

The main objective of this thesis was to characterize the physical activity behaviours of first year students over the academic year. It is well recognized that engagement in regular physical activity helps with weight maintenance and weight loss. Therefore, students that regularly participate in physical activity at the recommended level during their first year in university would be expected to maintain their weight [20].

However, multiple studies have reported a trend of reduced physical activity among first year university students [38].

The FITT principle (measuring frequency, intensity, time and type of physical activity) was used to provide a detailed analysis of the physical activity results obtained from this study. Frequency, defined as the times per week physical activity was performed, was assessed using the Determinants of Physical Activity Questionnaire. First, it was observed that there were no significant changes in the amount of free time spent being physically active in high school compared to university among males. The majority of males reported that they were physically active 3-4 times per week in their free time. It is possible that males demonstrated increases in lean body mass over the year due to this maintenance of free time physical activity as seen in Figure 4. Significant changes in free time physical activity were observed among females. The majority of females reported being physically active 1-2 times per week in their free time at the end of the year. This result was due to a shift in the data, as there were large reductions in the number of females that reported being often (3-4 times per week) or very (7+ times per week) physically active in their free time from the beginning of the year. This shift towards a reduction in free time physical activity was likely related to the increase in fat mass observed over the year in females. Second, we observed that the number of organized sports that males and females engaged in decreased from high school to university. Significant increases were observed among both males and females who engaged in 0-2 organized sports, however this was reflective of the decrease in both males and females who participated in 3-5, 6-8, 9-11, and 12+ organized sports in

university. Possibly, as the academic time pressures of university increase, students perceive that they have less time to participate in organized sports [65].

Intensity, described as the amount of effort expended during physical activity, and time, described as the amount of time spent being physically active, were assessed by the 2014 Block Food Frequency and Activity Questionnaire. Significant reductions were observed in energy expenditure, light, moderate, and vigorous physical activity minutes, and MET minutes over the year, in both males and females. Canada's physical activity guidelines from CSEP recommend that adults aged 18-64 should engage in at least 150 minutes of moderate to vigorous physical activity per week, in bouts of 10 minutes or more, to achieve health benefits [31]. Our results demonstrate that males decreased their moderate to vigorous physical activity minutes from 147 minutes per week to 98 minutes per week. Females' moderate to vigorous physical activity dropped from 139 minutes per week to 61 minutes per week. Only 24.5% of the male participants and 13.9% of the female participants engaged in the recommended 150 minutes of physical activity per week at the year end. This observation is in fact worse than what has previously been reported. Pinto et al. (1995), revealed that in a sample of 217 freshman, 42% of men and 50% of women reported being inactive or engaging in less than the recommended amount of activity per week [38]. Although our results do not support this observation, Jung et al. (2008) observed that a reduction in physical activity was the defining characteristic of weight gain in first year university students [39]. Moreover, Sparling and Snow (2002), observed that students who were inactive in university were more likely to be inactive later on in life [24]. Physical activity is an important factor for both weight gain

prevention and maintenance of health [66]. Moderate and vigorous physical activity minutes were also examined by Faculty and program of study. As we are from the department of Kinesiology, we were interested in assessing the results of the Kinesiology students compared to everyone else. Among those studying Kinesiology, males decreased their moderate to vigorous physical activity minutes from 155 to 88 minutes per week, and females decreased their moderate to vigorous physical activity from 124 to 55 minutes per week. Among those in other programs, males decreased their moderate to vigorous physical activity minutes from 144 to 99 minutes per week, and females decreased their moderate to vigorous physical activity from 143 to 63 minutes per week. The changes in physical activity minutes were not significantly different based on program of study. In fact, by the end of first year university, Kinesiology students spent less time in moderate to vigorous activity than the students in other programs/faculties, although this was not significant. This result was a surprise as it was thought that students in Kinesiology were both aware of Canada's recommendations for physical activity and that they understand the health benefits of being physically active. This result demonstrates the importance of introducing new strategies to combat physical inactivity among university students, as even those who understand the benefits of physical activity are still not meeting the recommended levels.

Type, described as the type of physical activity engaged in, was assessed by the Determinants of Physical Activity Questionnaire. First, significant reductions in physical education classes, competitive sports, and recreational sports were observed among both males and females over the academic year. This result was expected as physical education classes are not required in university and only those studying Kinesiology have

the option of enrolling them. Additionally, competitive sports at the varsity level are often at a higher level of competition and require a greater time commitment than competitive sports in high school, which could explain the decrease in competitive sport participation. No changes were seen among participation in intramural activities for either males or females, suggesting that students who participated in intramurals in high school were likely to continue participating in intramurals in university. Other activities, such as weight lifting, significantly increased among males. Most high schools do not have weight rooms, therefore it makes sense that upon entering university, where gym memberships are included with student fees, that the number of males engaging in weight training would increase. This was most likely a major contribution to the increase in lean mass that was observed in males over the year.

Second, we observed that the frequency of participation in both endurance sports (including: biking, cross-country skiing, floor hockey, jog/running, ice skating, in-line skating, skipping, street hockey, skateboarding, tag, and walking for exercise) and team sports (including: badminton, baseball, basketball, football, ice hockey, rowing, swimming, soccer and volleyball) significantly decreased from high school to university in both males and females. Females also demonstrated a slight increase in fitness activities, including fitness classes, dance and yoga, however the change was not significant.

Recent studies have reported similar findings. Jung et al. (2008) reported that physical activity (MET h/week) declined from the beginning to end of first year university [39]. Significant reductions were also observed in total occupational, work and sport activities by Butler et al. (2004) however they did not distinguish between light,

moderate, or vigorous physical activity minutes or MET minutes [36]. Racette et al (2005) observed that while overall exercise participation did not change, aerobic exercise behaviour declined and stretching exercises increased [67]. Research by Holm-Denoma et al. (2008) observed that males tended to engage in more high intensity exercises and females engaged in more low intensity exercises, however these trends were non-significant [27]. In contrast to our results, they reported that physical activity frequency remained the same during first year university. Therefore, our results are congruent with most of the existing literature, and support the observation that physical activity frequency, intensity, time and type decrease over first year university

While physical activity is a key variable that tends to change during the transition into first year university, there are still many inconsistencies in the physical activity literature. The main reason for this is that, as of yet, there is no one standardized method of assessing physical activity [4]. Despite this, our study has carried out a detailed measure of physical activity in these first year students, including measures of energy expenditure, light, moderate, and vigorous physical activity minutes, MET minutes, frequency of free time physical activity, level of physical activity, organized sport participation, and types of sport participated in. To our knowledge, our study is the only one of its kind to undertake such an extensive assessment of physical activity participation in this population.

The current study also examined the perceived barriers that affected students' involvement and participation in various types of physical activity. Understanding the determinants of students' physical activity behaviours is an important step in developing strategies to change these behaviours, if they are adverse. Significant increases in

intrapersonal factors such as shyness, stress, perceived self-skill, past bad experiences, lack of interest and fear of failure, as barriers to physical activity participation were observed among males and females. Past research has suggested that an individual's physical activity history (such as physical activity in high school) was related to levels of physical activity observed in university. Individuals who had positive experiences in their physical activity history had a greater likelihood of continuing to be physically active in university [38]. In addition, it has been reported that students in university are more likely to participate in physical activities that they already feel competent performing [68]. This could be reflective of the fact that while in high school most students participate in organized sports and recreational activities. Many high schools do not have weight rooms where students can learn the basics of resistance training, and therefore is it plausible that some first year students, especially females, might not feel competent in performing resistance training in gym settings at university.

Significant increases were also observed among interpersonal factors, such as lack of friends, peer influence, gender, ethnic background, perceived body image, and age, as barriers to physical activity participation among males and females. Research has demonstrated that social support and positive social pressure from friends are strong motivators to engaging in physical activity among males and that social support from family members is a strong motivator to engaging in physical activity among females [69]. Perhaps as students approach the end of the year, their family and peers are more likely to encourage them to study rather than be physically active. It has also been reported that individuals with negative body image are less likely to engage in physical activity in public gym settings than those with positive body image [70]. It is possible

that students' weight gain was associated with negative body image thus making them perceive their body image as a barrier to being physically active.

Significant increases were also observed among structural factors such as employment, homework, class schedule, income, distance of residence, lack of advertising, available free time, transportation, participation fees, sports offered, and overcrowded facilities, as barriers to physical activity participation among males and females. Economos et al. (2008) observed that academic stressors (homework, class schedule, free time) were negatively associated with physical activity participation in university [69]. As students' course loads increase and they experience more academic stress they are less likely to devote their free time to physical activity. In addition, they also demonstrated that distance of residence, sports offered, and overcrowded facilities are barriers to physical activity among university students. Therefore, these structural factors, including the proximity of the residence and characteristics of the facilities should be considered when promoting physical activity to first year students.

5.4 Physical Activity, Weight and Body Composition

Reductions in physical activity have been cited as one of the main predictors of weight gain among first year students [60]. Results from our analysis revealed that neither weight and body composition change nor weight and body composition at the end of the year were significantly correlated with changes in energy expenditure, light, moderate, and vigorous physical activity minutes or MET minutes. As significant changes were observed in both body weight and body composition, as well as physical

activity output variables, it is likely that the weight changes may be driven more by other factors affecting this transition such as dietary intake.

5.5 Strengths

The present study had several strengths. First, the sample size (*n*=301) was relatively large compared to similar studies. Second, the study included measures of body composition, allowing for further insight on the changes in weight that occurred. Very few studies of this nature have measured body composition, and of those that did, the majority only reported changes in body fat and did not include reports of the changes in lean and fat mass (kg). Our analysis of body composition allowed us to observe that although both sexes experienced changes in weight, the composition of this weight change was very different. We tend to demonize weight gain in society, and consider all weight gain to be bad. However, the weight gained by the male participants was in fact healthy weight, and without this analysis, this observation would have been missed and we would have thought the males gained unhealthy weight. Additionally, the BMX device has been shown to produce valid results, and enabled us to overcome the limiting factor of participant hydration status that affects BIA. Third, despite the lack of a uniformed measurement tool to assess physical activity behaviours, we employed a comprehensive analysis of physical activity behaviours. Our questionnaires examined measures of energy expenditure, light, moderate, and vigorous physical activity minutes, MET minutes, frequency of free time physical activity, level of physical activity, organized sport participation, types of sport participated in, and the perceived barriers

that affect students' physical activity participation. This detailed analysis of physical activity behaviours among first year students is likely the most in-depth study of its kind.

5.6 Limitations

First, our study required students to have their weight and body composition measured twice over the year. It is possible that a selection bias may have affected our results as those who chose to participate in the study might have had a personal interest in health. However, while this may be true, this purported personal interest in health did not translate into positive physical activity changes. Additionally, this study had a 75% attrition rate, therefore had 92 drop-outs. While we did not assess the characteristics of the drop-outs, it is possible that due to the nature of our study (asking about physical activity and body composition) the drop-outs may have been sensitive to this type of questioning and therefore did not come back for post-testing. Second, the well-established and validated Food Frequency and Activity Questionnaire (FFAQ) was used to measure physical activity output of the students. This questionnaire was not designed specifically for students (for example several questions asked about yard work, childcare, office work, and other activities that might not apply to students) , therefore it is possible that the physical activity habits of the sample population were not accurately captured. Additionally, the majority of the physical activity questionnaires relied on participant recall, which has been shown to produce variable and under-reported results [55]. Despite this limitation, assessing physical activity based on recall using questionnaires like the Godin-Sheppard Questionnaire or the one we used is still the most widely accepted method for assessment in research. Also, although the questionnaires we employed were

designed to be self-explanatory, subjects answered two of the questionnaires online and therefore did not have the chance to ask study personnel any questions they might have had. This may have affected the results. Additionally, as there is currently no uniform method for assessing physical activity (although as mentioned above, questionnaires are widely used), it is possible that our results may differ from results of similar studies that used different methods of assessment.

5.7 Implications and Future Directions

This thesis has several practical implications for students, universities and other investigators. First it provides evidence on the actual weight gain and body composition change that first year students at Brock University can expect to experience, and note that this 'gain' is substantially less than what is the current prevailing view in popular culture. Despite this, it is still important for students to recognize that seemingly minor changes in weight, body composition and exercise habits can result in negative health consequences and large changes in weight and body composition over time [29].

Second, university health promoters must be aware that promoting healthy lifestyle behaviours early in university may have long-term effects on reducing the prevalence of inactivity, overweight and obesity in both university and in society. There are several strategies that university health promoters could employ on campus, including providing seminars on how to make healthy choices and manage time appropriately in order to fit exercise into their routine in university. Many students entering university have never lived away from home before and may need guidance on how to maintain healthy physical activity and dietary habits. Brock University has created the LEAP

(Leadership, Engagement, Achievement, Pride) program and the Base Camp program which help incoming students get acquainted with university with the goal of easing students' anxiety of living away from home by showing them how to get involved on both campus and within the community. However, both these programs only run before the academic year begins. Student health and fitness centers could offer support groups to first year students and programs teaching about weight management than run throughout the year.

Third, Brock University could use the information provided by this thesis to make changes to the Kinesiology program. For example, implementing a mandatory fitness requirement of engaging in 150 minutes of moderate to vigorous physical activity per week in order to remain in the program would encouraged these students to incorporate more physical activity into their daily lives.

Finally, other investigators can use this information to develop studies that focus on increasing physical activity among university students. Research suggests that combatting the sedentary lifestyles of students is a challenge as students will not increase their physical activity levels just because they are told they should [4, 29]. For this reason, interventions that are curriculum based and provide students with physical activity labs as well as informative lectures could be an effective strategy to promote being active.

5.8 Conclusions

In summary, this study followed a sample of 301 students during their first year of study at Brock University, and found significant increases in weight, waist and hip

circumference, BMI, and body composition across the sample. These increases in anthropometrics and body composition were accompanied by reductions in physical activity output, including energy expenditure, light, moderate, and vigorous activity minutes and MET minutes. This study also demonstrated that frequency of free time physical activity, level of physical activity, organized sport participation, types of sport participation, and the perceived barriers that affect physical activity participation changed over the academic year resulting in overall reductions in energy expenditure and physical activity. However, while the reductions in physical activity behaviours were statistically significant, they were not correlated with the changes in anthropometrics and body composition. This study contributes to the literature by providing an in-depth analysis on the changes that occur in students' physical activity habits and behaviours as they transition from high school and undergo their first year of university, and on the factors that promote or dissuade them from being physically active. Data from this study should be used to support the development of interventions to promote physical activity and healthy lifestyles among first year university students.

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APPENDIX 1

1.1. Recruitment Poster

VOLUNTEERS NEEDED FOR RESEARCH STUDY!!
Department of Kinesiology

PURPOSE OF STUDY: To identify the key health-related issues and lifestyle changes that may occur as students' transition from high school to university and undergo their first year in university.

CRITERIA:

- NEW Brock University students entering 1st year
- 17-20 years old
- English Speaking
- Exclusion: if you are transferring programs within Brock or have already completed a first year of university elsewhere.

PARTICIPATION:

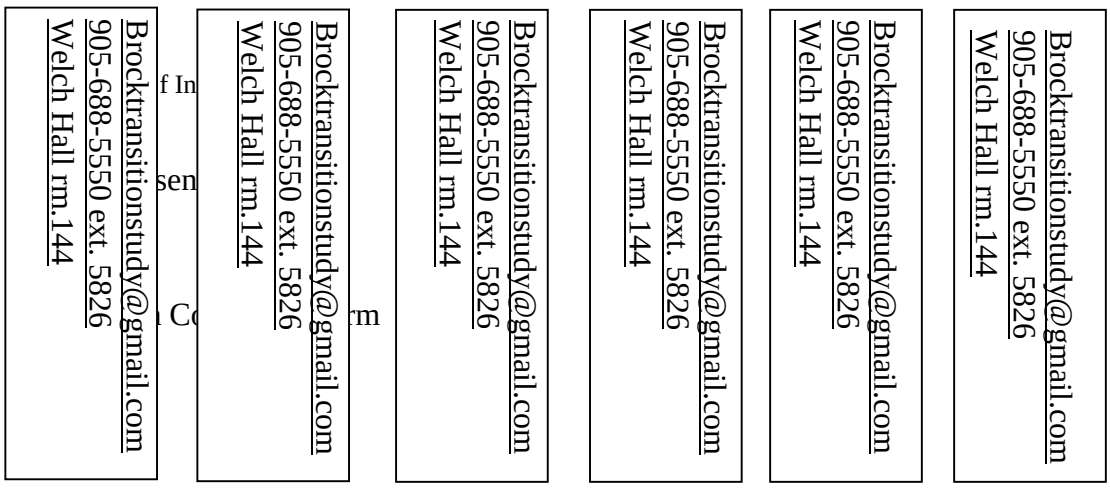
- How often and how long: only 2 time points, 2 hours each time point for a total of 4 hours
- Where: Nutrition Laboratory (WH144) and online
- What: answering a series of questionnaires about diet, exercise habits, body image, giving a saliva sample, measuring body composition

CHANCE TO WIN 1 of 2 BROCK BOOKSTORE GIFT CARDS of $100 each!!!
PAYMENT of $10 CASH upon completion of both sessions!!

CONTACT INFORMATION:

- Brock Transition Study Office is in WH144.
- brocktransitionstudy@gmail.com or 905-688-5550 ext 5826.

This research has been reviewed and received ethics clearance through the Research Ethics Board at Brock University (REB# 13-297). If you have any questions about your rights as a research participant please contact the Research Ethics Office at 905-688-5550 x 3035 or reb@brocku.ca



1.2 Letter of Invitation

Faculty of Applied Health Sciences
Department of Kinesiology

INVITATION LETTER

Identifying lifestyle changes that impact students' physical and emotional wellbeing during their first year of university

Dear students,
We would like to invite you to participate in a research study.
INVESTIGATORS: Dr. Andrea Josse (x. 3502), Dr. Nota Klentrou, Dr. Kimberley Gammage, Dr. Bareket Falk and Dr. Cameron Muir. We are from the Faculties of Applied Health Sciences and Social Sciences.
PURPOSE OF THE STUDY: To identify the key health-related issues and lifestyle changes that may occur as students' transition from high school to university and undergo their first year in university. We would also like to investigate whether ethnicity and gender play a role. Specifically, we will be assessing changes in nutrition, exercise and sleep habits, as well as changes in stress levels, body image, body weight and body composition during this time.
INCLUSION CRITERIA: You may participate in this study if you are entering your first year at Brock University, you are between the ages of 17-20, and you speak and understand English.

EXCLUSION CRITERIA: You are not eligible to participate in this study if you are transferring programs within Brock or have already completed a first year of University elsewhere.

TIME COMMITMENT: There are 2 time points in this study and 2 hours per time point. The total time commitment involved is 4 hours. Each time point consists of a 1 hour visit to the Nutrition Laboratory (WH144) and 1 additional hour to fill out online surveys. Testing sessions will be in late-August/September and March/April. Upon completion of both time points, you will receive $10 and be eligible to win 1 of 2 Brock Bookstore gift cards of $100 each. Also, depending on what department you are in, you may be eligible to receive a mark in a class for participation.
STUDY PROCEDURES: If you agree to participate in this study, you will be asked to:

1. fill out a series of questionnaires pertaining to nutrition, exercise, body image, sleep, stress and mental health (most online and 1 on paper).
2. undergo body measurements (height, weight, waist circumference, hip circumference).
3. undergo body composition measures in 2 ways (Bioelectrical Impedance Analysis and Ultrasound).
4. provide a saliva sample.

If you are interested in finding out more about this study, please contact our study office by email (brocktransitionstudy@gmail.com) or by phone (905-688-5550 ext: 5826).

This research has been reviewed and received ethics clearance through the Research Ethics Board at Brock University (REB# 13-297). If you have any questions about your rights as a research participant please contact the Research Ethics Office at 905-688-5550 x 3035 or reb@brocku.ca

Thank you,
TRANSITION Project investigators

1.3 Consent Form

CONSENT TO PARTICIPATE IN A RESEARCH STUDY

STUDY TITLE: Identifying lifestyle changes that impact students' physical and emotional wellbeing during their first year of university

You are being invited to participate in a research study conducted by the investigators listed below. Prior to participating in this study please read this form to find out about the purpose of our study and what is required of you should you choose to participate. All testing will be carried out in the Nutrition Laboratory (WH144, Brock University) or online.

INVESTIGATORS:	DEPARTMENT:	CONTACT:
Dr. Andrea Josse	**FAHS, Brock University**	**(905) 688-5550 ex. 3502**
Dr. Nota Klentrou	FAHS, Brock University	(905) 688-5550 ex. 4538
Dr. Kimberley Gammage	FAHS, Brock University	(905) 688-5550 ex. 3772
Dr. Bareket Falk	FAHS, Brock University	(905) 688-5550 ex. 4979
Dr. Cameron Muir	FSS, Brock University	(905) 688-5550 ex. 4681

PURPOSE: The purpose of our study is to identify the key health-related issues and lifestyle changes that may occur as students' transition from high school to university and undergo their first year in university. Specifically, we are assessing the changes in nutrition, exercise and sleep habits, stress levels, body image, mental health and anthropometry (body weight and body composition) during this critical period.

INCLUSION CRITERIA: You may participate in this study if you are entering your first year at Brock University, you are between the ages of 17-20, and you speak and understand English.

EXCLUSION CRITERIA: You are not eligible to participate in this study if you are transferring programs within Brock or have already completed a first year of University elsewhere.

STUDY TIMELINE: Should you consent to participate, you will be asked to fill out several surveys online and come to the Nutrition Laboratory on campus (WH144) in the morning hours on two occasions (2 time points). Testing sessions are identical and will be approximately 8 months apart. Thus, the testing sessions will take place at the start and end of the academic year (September and April). Each of the 2 testing sessions will last approximately 1 hour online and 1 hour in the laboratory. The total time commitment involved will add up to 4 hours. You will be asked to fill out a series of questionnaires online prior to your laboratory visit, and in the lab, you will fill out one more questionnaire asking about eating habits. If preferred, you may request to fill out all surveys in person as opposed to online. You will then have your height, weight, waist circumference, and body composition measured, and you will provide a saliva sample. Two or 3 participants will be scheduled to visit the lab simultaneously, however all measurements will be taken individually and privately, and if requested, by a same-sex investigator. All procedures are detailed below.

DESCRIPTION OF TESTING PROCEDURES: You will be asked to arrive at the Nutrition Laboratory for your scheduled testing session. Please refrain from eating or drinking anything for **4 hours** prior to this testing session. Please refrain from exercise for **12 hours** and from alcohol for **24 hours** prior to this testing session. Students of the study investigators will be facilitating the testing and taking the measures. Specific testing procedures are outlined below.

1. **Questionnaires:** You will be asked to complete questionnaires online (using Fluid Survey) and one questionnaire on paper (the Food Frequency Questionnaire) on three occasions. These questionnaires will ask about your general health and demographics, medical history, exercise, nutrition, sleep habits, stress levels, body image and mental

health. Remember that your responses will be kept confidential and that you may choose not to answer any question without penalty. All online data will be stored on Canadian servers and then downloaded to our password protected laboratory computers for further analysis. Only your subject ID will be used as an identifier, i.e. those analyzing the data will not know who filled out the survey, only their subject ID.

2. **Body composition:** We will measure your body composition (% body fat) in two ways on three occasions. The first is using BIA, which stands for "Bioelectric Impedance Analysis". The BIA assessment requires you to stand on a weight scale and grasp two handles. A mild electrical current (50kHz, 800µA) will pass through your hands to your feet. This current cannot be felt and causes no harm. Valid measurements require abstinence from exercise, alcohol consumption, and eating/drinking for at least 12, 24 and 4 hours, respectively, prior to testing. You will be asked to consume 1 bottle of water (500 mL) at the start of the visit and then void prior to BIA measures being taken. Body composition will also be assessed using the BodyMetrix system. The BodyMetrix system uses ultrasound to accurately measure fat thickness in your thigh and calculate % body fat. There is no discomfort associated with either measurement.
With bioelectrical impedance analysis (BIA), body composition will be measured by having you stand on a weight scale putting your feet on electrode plates while holding electrode wands in your hands (as mentioned above). With the BodyMetrix ultrasound device, body composition will be measured on the top part of your thigh. Waist circumference will be measured using a standard, retractable, non-metallic tape measure placed at your waist at the level of your belly button. Hip circumference will be measured using the same tape measure across the largest part of your buttocks and below your 'hip bones'.

3. **Saliva sample:** We will ask you to provide a saliva sample at each visit to determine your salivary cortisol (stress hormone) and testosterone levels. Saliva samples must be collected in the morning hours. The samples will be collected using specifically designed cotton ball/swabs which are to be placed between your cheek and teeth. You will hold the swab there for 1 minute and then place it into labeled tubes for storage. You will be asked to follow these additional procedures and answer additional related questions prior to collection:

    a. Avoid foods with high sugar or acidity, or high caffeine content, 4 hours before sample collection.

    b. Document consumption of alcohol, caffeine, nicotine, and prescription/over-the-counter medications as well as physical activity within the prior 12 hours.

    c. Document the presence of oral diseases or injury.

    d. Do not eat a major meal within 60 minutes of sample collection.

    e. Rinse mouth with water to remove food residue and wait at least 10 minutes after rinsing to avoid sample dilution before collecting saliva.

CONFIDENTIALITY: All of your data collected during this study will remain confidential and will be stored in offices and on secured computers to which only the principal and co-investigators have access. You should be aware that the results of this study will be made available to scientists, through publication in a scientific journal but your name and any personal data will not appear in compiling or publishing these results. Electronic and paper data will be kept for 5 years after the date of publication, at which time all information will be destroyed. Additionally, you will have access to your own data, as well as group data when it becomes available and if you are interested. Once the study is completed, if you wish to be contacted to learn of the results of the study and/or to participate in future studies directly relating to this one (e.g. focus groups) please indicate this on the last page of this form.

PARTICIPATION AND WITHDRAWAL: You can choose whether to participate in this study or not and may remove your data from the study if you wish at any time. You may also refuse to answer any questions posed to you during the study and still remain a participant in the study. There will be no effect on your academic standing or standing within the university if you choose to withdraw from the study at any time. The investigators reserve the right to withdraw you from the study if they believe that it is necessary. Upon completion of both time points, you will receive $10 and be eligible to win 1 of 2 Brock bookstore gift cards of $100 each. Also, depending on what department you are in, you may be eligible to receive a mark in a class for participation.

RISKS AND BENEFITS: There is little direct risk to you. You may experience some discomfort due to the personal nature of the questions asked. You may also feel uncomfortable during the body composition test. This study poses no physical risk. Participation will allow you to become exposed to a research protocol, contribute to the advancement of science and, gain general knowledge about lifestyle habits of first year students at Brock University.

RIGHTS OF RESEARCH PARTICIPANTS: You may request to receive a signed copy of this consent form. You may withdraw your consent to participate in this study at any time, and you may also discontinue participation at any time without penalty. This research has been reviewed and received ethics clearance through the Research Ethics Board at Brock University (REB# 13-297). If you have any pertinent questions about your rights as a research participant, please contact the Brock University Research Ethics Officer (905 688-5550 ext 3035, reb@brocku.ca).

INFORMATION: Our study office is located in Welch Hall 144. Please contact our study office at brocktransitionstudy@gmail.com or 905-688-5550 ext. 5826, or any of the above investigators at any time if you have any questions about the study.

1.4. Data Collection Form

Participant ID # _____

Transition Study – BREB# 13-297

Anthropometrics and Body Composition Log Sheet

Name: _____ Birthday: _____ Age:_____

Date: _____

Time of visit: _____ Visit (circle): 1st 2nd

Fasted: Y N **Program: _____**

ANTHROPOMETRY

Measurements taken by: _____

Body weight (kg): _____ (lbs): _____

Height (cm): _____ (in): _____ (ft-In): _____

BMI: _____

Waist Circumference @ umbilicus (cm): _____

True waist (females): _____

Hip Circumference (cm, across the largest part of buttocks): _____

How were measures done? (i.e. over clothes, under clothes):

_____

What type of clothes were worn:

_____

BODY COMPOSITION DATA FORM

BodyMetrix System

FEMALE

Personal ID: _____
Fat Thickness: Thigh: _____ Chest: _____ Waist: _____ Scapula: _____ Triceps: _____
% Body Fat: _____
Lean Body Mass: _____
Total Fat Mass: _____
BMI: _____
BMR (Basal Metabolic Rate): _____

MALE

Personal ID: _____
Fat Thickness: Thigh: _____ Hip: _____ Triceps: _____ Waist: _____
% Body Fat: _____
Lean Body Mass: _____
Total Fat Mass: _____
BMI: _____
BMR (Basal Metabolic Rate): _____

InBody520 BIA System:

Bottle of water consumed: Y N

Void: Y N

% Body Fat: _____
BMI: _____
Intracellular water: _____
Extracellular water: _____
Total body water: _____
ECW / TBW: _____
BMR: _____

Menstrual cycle present during testing: Y N MALE

APPENDIX 2 : Questionnaires

2.1 Determinants of Physical Activity Questionnaire – PRE/POST

Using the five-point Likert scale below, please rate the extent that each of the following participation barriers affected your recreational involvement before/during university.

For the following 3 questions, please only circle one number per statement and use the scale below:
1 – Not a barrier
2 –
3 – Somewhat of a barrier
4 –
5 – Major barrier

Intrapersonal Factors

	1	2	3	4	5
Shyness					
Stress					
Perceived self-skill					
Past bad experiences					
Lack of interest					
Fear of failure					

Interpersonal Factors

	1	2	3	4	5
Lack of friends to participate with					
Peer influence					
Gender					
Ethnic background					
Perceived body image					
Age					

Structural Factors

	1	2	3	4	5
Employment					
Homework					
Class schedule					
Income					
Distance of residence from school					
Lack of advertising					
Available free time					
Transportation					
Participation fees					
Sports of interest not offered					
Overcrowded facilities					

While in high school (university), how many sporting activities did you participate in that were organized and run by your high school (university)?
Please circle the appropriate answer.

1. 0-2
2. 3-5
3. 6-8
4. 9-11
5. 12+

Which of the following levels of recreation did you participate in while in high school (university)?
Please circle all that apply.

1. Physical education
2. Intramurals
3. Competitive organized sports
4. Out of school sports
5. Other – Print here: _____

2.2 Physical Activity Questionnaire for Adolescents – PRE/POST

Physical activity in your spare time: Have you done any of the following activities in the past few months (during your first year)? If yes, how many times? (Check only one box per row).

	None	**1-2**	**3-4**	**5-6**	**7-8**	**9+**
Biking						
Cross-country skiing						
Floor Hockey						
Jog/Running						
Ice skating						
In-line skating						
Skipping						
Skateboarding						
Street hockey						
Tag						
Walking						
Badminton						
Baseball						
Basketball						
Football						
Ice hockey						
Rowing						
Swimming						
Soccer						
Volleyball						
Aerobics						

Dance						
Martial arts						
Yoga						

Which one of the following describes you best for the last few months before entering (during) university?
Read all five statements before deciding on the one answer that describes you.

1. All or most of my free time was spent doing things that involve little physical effort.
2. I sometimes (1-2 times per week) was physically active in my free time.
3. I often (3-4 times per week) was physically active in my free time
4. I very often (7+ times per week) was physically active in my free time.

2.3 2014 Block Food Frequency Questionnaire – PRE/POST

FOOD AND ACTIVITY QUESTIONNAIRE

RESPONDENT ID #

TODAY'S DATE

Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec

DAY YEAR

2014 2015 2016 2017 2018 2019 2020 2021 2022 2023

ABOUT YOU

SEX
Male
Female

AGE

WEIGHT pounds

HEIGHT feet inches

If female, are you pregnant or breast feeding?
No
Yes
Not female

ABOUT THIS SURVEY

Please answer each question as best you can. Estimate if you aren't sure.

- **DETACH THE LAST PAGE OF THIS BOOKLET.** These are your portion pictures.
- **USE ONLY A NUMBER 2 PENCIL.**
- **FILL IN THE CIRCLES COMPLETELY** and erase completely if you make any changes.

INSTRUCTIONS

This form is about the foods you usually eat. Think about your intake over the last 6 months. This includes all meals or snacks, at home, in a restaurant, or carry-out.

Please tell us...

1. **HOW OFTEN,** on average, did you eat the food?
   DO NOT SKIP any foods. Mark "Never" if you didn't eat any of the food.
2. **HOW MUCH** of the food did you usually eat on the days you ate it?
   Sometimes we ask "how much" as A, B, C or D. **LOOK AT THE PORTION PICTURES.**
   Pick the picture that looks the most like the serving size you usually eat.
   (If you don't have pictures: A=1/4 cup, B=1/2 cup, C=1 cup, D=2 cups.)
3. **WHAT TYPE?** For some foods we ask the type (low-fat, low-sugar...) near the end of the survey.

EXAMPLE: This person drank orange juice twice a week, and had one glass each time.
Once a week this person ate a "C"-sized serving of cold cereal (about 1 cup).

	HOW OFTEN in the past 6 months?									HOW MUCH on those days? SEE PORTION SIZE PICTURES FOR A-B-C-D
	NEVER	A FEW TIMES PER 6 MONTHS	ONCE per MONTH	2-3 TIMES per MONTH	ONCE per WEEK	2 TIMES per WEEK	3-4 TIMES per WEEK	5-6 TIMES per WEEK	EVERY DAY	
Orange juice	○	○	○	○	○	●	○	○	○	How many glasses ● 1 ○ 2 ○ 3 ○ 4
Cold cereal	○	○	○	○	●	○	○	○	○	Which bowl ○ A ○ B ● C ○ D

PLEASE DO NOT WRITE IN THIS AREA

SERIAL #

Block 2014.1_6Mo ©www.NutritionQuest.com Phone 510-704-8514

SOME LAST QUESTIONS ABOUT YOU

	RARELY	1-2 per WEEK	3-4 per WEEK	5-6 per WEEK	1 per DAY	1 1/2 per DAY	2 per DAY	3 per DAY	4+ per DAY
About how many servings of vegetables do you eat, not counting salad or potatoes? 1 serving = 1/2 cup.	○	○	○	○	○	○	○	○	○
About how many servings of fruit do you eat, not counting juices? 1 serving = 1/2 cup or 1 medium fruit.	○	○	○	○	○	○	○	○	○
How often do you eat foods prepared at home that are cooked or fried in **fat or oil?**	○	○	○	○	○	○	○	○	○

During a regular day, how many **meals and snacks** do you usually eat?

Meals per day	○ 1	○ 2	○ 3	○ 4	○ 5+
Snacks per day	○ 1	○ 2	○ 3	○ 4	○ 5+

PHYSICAL ACTIVITY SURVEY

Think about the last 6 months. How often did you do the activities listed below?

	HOW OFTEN IN THE PAST 6 MONTHS						HOW MUCH TIME ON THOSE DAYS			
	RARELY OR NEVER	A FEW TIMES A MONTH	ONCE OR TWICE A WEEK	3-4 TIMES A WEEK	5-6 TIMES A WEEK	ALMOST EVERY DAY	LESS THAN 30 MINUTES	30-60 MINUTES	1-2 HOURS	3 OR MORE HOURS
Cooking, shopping, light cleaning like doing laundry or dusting, or running errands	○	○	○	○	○	○	○	○	○	○
Slow walking like walking the dog, or light work around the house like watering	○	○	○	○	○	○	○	○	○	○
Work on the job involving standing, like store clerk, or work involving driving (like truck driver)	○	○	○	○	○	○	○	○	○	○
Taking care of children (feeding, dressing), or moderate housework like sweeping, mopping, cleaning the tub	○	○	○	○	○	○	○	○	○	○
Weeding, raking, mowing the lawn, or light house repairs	○	○	○	○	○	○	○	○	○	○
Brisk walking, dancing, hunting or fishing, golf (NOT using a golf cart), or 'friendly' outdoor games like softball	○	○	○	○	○	○	○	○	○	○
Factory work, mechanic, restaurant work, or work involving walking, like mail carrier	○	○	○	○	○	○	○	○	○	○
Construction, painting, feeding livestock, or homecare like caring for an adult family member	○	○	○	○	○	○	○	○	○	○
Heavy work like moving boxes, heavy digging or shoveling snow, farm chores like baling hay, or other HARD labor	○	○	○	○	○	○	○	○	○	○
Exercising at the gym or at home, aerobics, weight training, jogging, or vigorous sports like basketball, soccer, tennis	○	○	○	○	○	○	○	○	○	○
Bicycling or swimming for exercise	○	○	○	○	○	○	○	○	○	○

Are you ○ Hispanic or Latino ○ Not Hispanic or Latino ○ Do not wish to provide this information

What race do you consider yourself to be? **MARK ALL THAT APPLY**

- ○ White
- ○ Black or African American
- ○ Asian
- ○ American Indian or Alaska Native
- ○ Native Hawaiian or Other Pacific Islander
- ○ Do not wish to provide this information

Thank you very much for filling out this questionnaire.

Please take a minute to go back and fill in anything you may have skipped.

PLEASE DO NOT WRITE IN THIS AREA

SERIAL #

3.1 Bioelectric Impedance Analysis Data

	Pre	Post	Change	Sig.
Body Fat (%)	**24.8 ± 8.9**	**26.4 ± 8.6**	**1.6 ± 4.6**	**0.000***
Males	15.8 ± 6.3	17.8 ± 6.8	2.1 ± 6.1	0.000*
Females	27.6 ± 7.5	29.0 ± 7.3	1.4 ± 4.0	0.000*
BMI	**23.2 ± 4.4**	**23.9 ± 3.9**	**0.7 ± 3.4**	**0.001***
Males	24.1 ± 3.1	25.2 ± 3.5	1.1 ± 2.2	0.000*
Females	23.0 ± 4.7	23.5 ± 4.0	0.5 ± 3.6	0.020*
LBM (kg)	**48.8 ± 10.6**	**49.1 ± 11.2**	**0.3 ± 4.5**	**0.215**
Males	63.8 ± 9.2	65.2 ± 8.7	1.4 ± 4.3	0.002*
Females	44.2 ± 5.9	44.2 ± 6.2	0.0 ± 4.4	0.947
FM (kg)	**16.3 ± 7.7**	**17.8 ± 8.2**	**1.5 ± 4.4**	**0.000***
Males	12.3 ± 5.7	14.8 ± 7.6	2.5 ± 6.0	0.000*
Females	17.6 ± 7.8	18.8 ± 8.2	1.2 ± 3.6	0.000*
ICW	**22.3 ± 5.0**	**22.6 ± 5.3**	**0.3 ± 1.8**	**0.001***
Males	29.4 ± 4.3	30.1 ± 4.0	0.6 ± 1.7	0.001*
Females	20.1 ± 2.6	20.3 ± 2.9	0.2 ± 1.8	0.021*
ECW	**13.4 ± 3.1**	**13.9 ± 7.9**	**0.6 ± 7.5**	**0.200**
Males	17.3 ± 2.4	17.7 ± 2.3	0.4 ± 1.0	0.001*
Females	12.2 ± 2.1	12.8 ± 8.7	0.6 ± 8.6	0.274
TBW	**35.3 ± 7.8**	**36.0 ± 8.1**	**0.7 ± 3.3**	**0.000***
Males	46.2 ± 7.0	47.7 ± 6.3	1.5 ± 4.2	0.003*
Females	32.0 ± 4.4	32.4 ± 4.3	0.4 ± 2.9	0.014*
ECW/TBW	**0.374 ± 0.006**	**0.374 ± 0.007**	**0.000 ± 0.005**	**0.154**
Males	0.375 ± 0.006	0.370 ± 0.006	0.0 ± 0.0	0.620
Females	0.376 ± 0.006	0.376 ± 0.007	0.0 ± 0.0	0.181
BMR	**1420.6 ± 230.6**	**1432.7 ± 237.6**	**12.1 ± 87.1**	**0.170**
Males	1742.0 ± 212.8	1772.9 ± 189.4	30.9 ± 127.6	0.032*
Females	1321.3 ± 126.2	1327.6 ± 126.5	6.3 ± 68.3	0.098

Data are represented as means ± standard deviation.
*Significance was set as $p<0.05$. P values relate to paired sample t-test (post-pre).
BMI = body mass index, LBM = lean body mass, FM = fat mass, BMR = basal metabolic rate.